PRINTING INKS

TYPOGRAPHIC TECHNICAL SERIES FOR APPRENTICES—PART I, NO. 12

PRINTING INKS

THEIR COMPOSITION, PROPERTIES AND MANUFACTURE

REPRINTED BY PERMISSION FROM CIRCULAR NO. 53
UNITED STATES BUREAU OF STANDARDS

TOGETHER WITH SOME HELPFUL SUGGESTIONS ABOUT THE EVERY-DAY USE OF PRINTING INKS

BY
PHILIP RUXTON

PUBLISHED BY THE COMMITTEE ON EDUCATION
UNITED TYPOTHETAE OF AMERICA
1918

Composition and electrotyping contributed by
The Plimpton Press
Norwood, Mass.

PREFACE

INK is "a substance employed for producing graphic tracings, inscriptions, or impressions on paper or similar materials. The term includes two distinct conditions of pigment or coloring matter: the one fluid, and prepared for use with a pen or brush, as writing ink; the other a glutinous adhesive mass, printing ink, used for transferring to paper impressions from type, engraved plates, and similar surfaces."

Without ink there could be no printing; hence ink is an essential element, and an intelligent knowledge of it is important to the printer.

The limits of this small book do not permit of an exhaustive study of printing ink, its chemical composition and properties, but the printing student will find set forth in these pages a few of the major facts regarding printing inks, their origin, development, ingredients, process of manufacture, and adaptation, followed by some simple rules that it is hoped will be found helpful.

Attention is directed to the Glossary wherein much additional information will be found in the brief definitions given of the chemical names and terms used in this treatise.

CONTENTS

HISTORICAL

IT is natural to think that printing inks should date back to the first printing press. In so doing we forget that to the Chinese many of our modern discoveries are very old stories.

It seems quite certain that as early as 50 B.C. a rather primitive method of printing was known to this people. It can readily be imagined that advances in the art of printing were rather difficult, for in the Chinese language each word requires a separate character and a job printer would require something over 15,000 characters to meet only the very ordinary demands of his work. However, as early as 927 A.D. certain volumes were printed from stone blocks for the Imperial College at Peking. In the printing of these books the characters were cut into the surface of the stone, so that when printed they appeared white on a black background. Shortly after, engraved blocks of wood were used on which the characters were raised, and the printed page appeared with black characters on a white paper. For ink the Chinese had at their disposal a very satisfactory black pigment which they had been using for writing purposes, the manufacture and properties of which were well known to them. It was merely necessary to mix this with an oil to get a fairly satisfactory printing ink.

In Europe printing as an art became quite general during the early part of the sixteenth century. Many specimens of this early work exist in the various museums and are of great interest. In some cases the ink has remained an intense black, with no sign of fading. This is no more than would be expected, for the pigment in these inks is principally carbon, one of the most stable pigments known. It may be accepted, however, as a general proposition, that the life of a printed page depends not upon the lampblack but upon the durability of the paper and of the oil which binds them together. In some of these early books, owing either to impure lampblack or inferior or improperly prepared oil, the printing has offset on the opposite page, a fault which occurs in books of modern times.

The early printer usually made his own ink, and the literature contains many stories of how the staff of the early printing shops would occasionally take a picnic in the fields, set up their kettles, and proceed to boil linseed oil, the festival culminating in a feast of bread which had been toasted in the hot oil. It would not be at all surprising if this early custom was responsible for the idea that bread made a good "oil drier," and was probably first established by a printer who found that on the day he had made a good varnish some of his apprentices had accidentally dropped their bread in the oil.

This scheme for making ink was not satisfactory. Too much time was lost and the ink did not always turn out well, so that by the seventeenth century it was quite common for the printer to buy his inks ready-made. That dishonesty, or ignorance in manufacture, is by no means confined to recent times is quite evident from the statement of Moxon, in his "Mechanik Exercises" (1683), when he says:

"The providing of a good inck or rather a good varnish for inck, is none of the least incumbent cares upon our master-printer, though custom has almost made it so here in England; for the process of making inck being as both laborious to the body, as noysom and ungrateful to the sence, and by several odd accidents dangerous of firing the place it is made in, our English master-printers do generally discharge themselves of that trouble; and instead of having good inck, content themselves that they pay an inck maker for good inck, which may yet be better or worse according to the conscience of the inck maker."

The history of ink making shows that the development of the industry followed the improvement of inks, to gain the desired consistency, along the following lines: First, the ink must have a certain body; second, it must have a certain cohesion, or flow (long or short); and third, a certain adhesion or tack. An ink or varnish is "long" when a drop falls away from a spatula with a long hairy string or thread; it is "short" when the drop is cut off sharply, with a very small tail.

There was considerable difference between the methods of the early English and Dutch ink makers. The latter used only linseed oil, with a small amount of added rosin, whereas the English added a considerable quantity of rosin, and even mineral oil, to an insufficiently boiled linseed oil.

The early varnishes [1] were almost invariably made by heating the oil to the point where the vapors would take fire (a red-hot poker was supposed to have special advantages in starting the burning), testing the burning oil from time to time, and stopping the process when the cooled sample showed that it had attained the desired consistency. The kettle was then covered, and when the oil was cold it was mixed with smoke black or lampblack, and the whole mass ground together with the old-fashioned muller stones. This

[1] Varnish, as used in the printing ink trade, has two general meanings — first, linseed oil which has been heated at or near its flash point, with or without permitting it to take fire; and second, the whole body of all the vehicles, or media which carry the pigments, even including the driers.

process is in use today in the preparation of varnish for plate inks.

The latter part of the eighteenth century developed the use of litharge in boiling the oil, but it did not receive universal commendation and was soon abandoned. The principal objection was that a varnish prepared with litharge clogged the type. The early part of the nineteenth century saw the introduction of soap, to make the ink leave a clean, sharp impression on the paper and to prevent the clogging of the type. It had the further advantage of thickening the ink, so that the oil did not have to be boiled, or burned, as long as would otherwise have been necessary.

In 1823 Savage, who had studied the manufacture of printing ink from the point of view of the practical printer, published a book in which he discussed the various methods of manufacture. His recommendation of old linseed oil brought forward an idea which has since received considerable attention from ink makers, viz., that the oil used for printing ink must be carefully purified. An old oil would, of course, be comparatively free from foots or sediment. In case such an oil is not available, mechanical means must be employed to clarify the fresh oils.

The eighteenth century developed the idea of adding a blue coloring matter to neutralize the yellow of the oil, using for this purpose Prussian blue and indigo. The nineteenth century saw the development of the aniline dye industry, following the synthesis, by Perkin, of mauve, the first aniline color.

Meanwhile, owing to a desire to reduce the cost of inks as well as to secure inks which would work better on the various grades of paper now being made, new oils were being introduced into the ink vehicles. First of all came the introduction of rosin and rosin oil, followed by mineral oil, the long gilsonites (the latter furnishing both vehicle and pigment), the semi-drying oils, and the new drying oils, such as China or tung oil, etc.

We thus arrive at the twentieth century, and find the materials for making printing inks pretty thoroughly studied, and in general very much what they were in the beginning. Recent advances have been along the line of the mechanical devices for the manufacture of large quantities at a minimum of cost. So far as materials are concerned the principal progress has been in the preparation of colored inks, used so effectively in the multi-colored lithographic work.

COMPOSITION OF PRINTING INKS

Classes of Ink

IT has been stated that the inks of today have for their foundation practically the same materials which have been used since printing ink was first made. The perfecting of the art of making paper, together with the development of rapid printing presses, have brought into use several rather distinctive types of ink. They may be divided into two classes — first, in which the paper is fed into the press in a continuous sheet, and second, in which the paper is fed in one sheet at a time. The newspaper is perhaps the best known example of the former; the latter includes a variety of materials, such as books, cards, illustrations, etc. The composition and consistency of each of these classes of ink will depend not only upon the class of work for which they are intended — i.e., the grade of paper to be used — but also upon the speed at which the presses are run and the temperature and humidity at the time of printing. The problem of selecting the proper grade of ink is therefore far from being as simple as it might appear at first sight.

In addition to the above, there are inks for special kinds of printing, such as lithographic work and engraving, the inks of the latter class being generally known as plate inks.

Still another grade of ink is the doubletone. This consists of a black pigment, such as carbon black, and a dye dissolved in oil. It is used extensively in illustration work, calendars, catalogs, etc., where its working qualities produce very artistic results.

The Government Printing Office divides its inks into four classes — web-press, flat-bed, job, and halftone — the particular properties of each kind depending upon the paper for which it is intended as well as the press upon which it is to be used.

Web-press ink is intended for use on presses where the paper is fed in a continuous sheet or "web." These presses are run at a very high speed, reaching at times from 10,000 to 12,000 revolutions per hour. The ink fountains are of the "overshot" type, i.e., the feed roll carries the ink up and over to the distributing rolls. Web-press inks must therefore be thin, so as to feed well and penetrate the paper rapidly, and must have considerable cohesion or length, in order that there shall be no break in the supply of ink. The penetration is of particular importance, especially when the ink is printed on both sides of the paper practically simultaneously, in order that there shall be as little offsetting as possible. On hard papers there may be an initial penetration of part of the ink, causing it to "set," followed by drying through oxidation. With soft paper there is no drying by oxidation, and all the drying must therefore come through penetration of the paper by the ink.

In this connection it is proper to state that if inks intended to dry by absorption only are used on hard papers they will not dry rapidly, and all sorts of trouble may result. In such cases the addition of driers will not promote the drying; the remedy is to change either ink or paper.

Flat-bed ink is used in printing the better class of books, pamphlets, etc. A somewhat heavier body is required than is the case in web-press work, the ink being somewhat thicker. The drying qualities must be adjusted to the paper used, and inasmuch as the flat-bed inks are generally used on harder paper than the web-press inks the former have usually better drying qualities, i.e., drying by both absorption and oxidation. This does not necessarily mean that flat-bed inks are always superior to web-press inks; there are good and bad of both classes.

The job ink is used on platen or flat-bed presses, for printing on highly sized papers, such as bond, ledger, writing papers, cardboard, etc.

Finally, there is the halftone ink, for use in printing from halftone plates on a highly glazed or coated paper.

The flat-bed presses have "undershot" ink fountains, and are not run at anything approaching the speed of the web presses. A stiffer ink is needed, and it need not be quite so "long" as the web-press ink.

In order better to understand the making of ink, it would perhaps be advisable to give a brief description of the materials entering into its composition.

Oils

Linseed Oil.[1] Linseed oil is contained in the seeds of the flax plant (*Linum usitatissimum*). It is very high in price, as oils go, and consequently can not be used in the cheap newspaper inks, but is unquestionably the best vehicle for the better grades. The chief virtue of this oil is that on exposure to air, in thin films, it dries rapidly to a hard surface, which adheres very firmly to the paper and is not readily affected by further exposure to light and air. Its importance is such as to warrant special notice, and in a later chapter it is proposed to deal with this material at some length, describing its manufacture and giving some of its properties.

Semi-drying Oils. There are some oils, such as corn oil, rapeseed oil, etc., which possess to some extent the

[1] See "Manufacture and Testing of Linseed Oil," p. 44.

property of drying on exposure in thin films. These oils are called semi-drying oils. They are not much used when linseed oil can be obtained at a reasonable price, but in the event that the price of linseed oil should become prohibitive they could be used as a substitute in the medium-grade inks.

Chinese Wood Oil. In recent years a new oil has appeared on the market, the Chinese wood oil or tung oil. So far as can be ascertained this has not been used in the manufacture of printing ink, but it is not unlikely that in the course of a few years it will be used to replace part of the linseed varnish. It has excellent drying qualities.

Rosin. Rosin (colophony) is the solid residue remaining in the stills after the distillation of turpentine. It comes in large, irregular lumps, the color of which varies from water-white to almost black. The lighter shades are somewhat transparent, while the darker are practically opaque. The variations in color are due partly to the manner of treatment and partly to the condition of the resins gathered from the tree. It is very brittle, being easily ground into a fine powder. It is readily melted, and in this condition is added to the oil in the preparation of printing inks.

Rosin Oil. When rosin is subjected to distillation it yields about 85 per cent of its weight of a heavy oil, known as rosin oil. This is used extensively in inks, especially in the cheaper varieties. It is not a substitute for linseed oil and should not be used as such. When mixed with rosin and suitable driers (generally organic salts of lead and manganese) it possesses some drying properties. Its great value lies in its ability to dry rapidly by absorption, since it readily penetrates soft papers.

Rosin and rosin oil find extensive use in the manufacture of printing inks and, in their proper place, are of great value, and should not be looked upon as adulterants. The material from which an ink is made is quite unimportant, provided it has the working qualities desired, does not injure the paper, press, type, plates, etc., and is at least as permanent as the paper upon which it is printed. Furthermore, distinction must be made between inks intended for printing work which will be thrown away in a very short time (newspapers, magazines, etc.) and inks intended for more or less permanent records. It has been shown by experience that, when used as a substitute for linseed oil, rosin and rosin oil are responsible for considerable trouble, just as linseed oil has been found objectionable when it has been used to replace rosin oil in inks demanding rapid absorption. In every case it is a question of fitting the vehicle to the work for which the ink is intended.

Hard Gums. The hard gums are the exudations from various species of tropical trees. The kinds used in printing inks are resins and not true gums; the latter term is more specifically applied to those which are soluble in water, such as gum arabic, etc., the water-insoluble gums being better known as resins. However, the collective name of hard gums is used so generally in the trade that it will be employed in this treatise in preference to the more scientific name of resins.

There is little uniformity in the classification of these gums; the same name is applied in different countries to entirely different kinds of gum. Here, those known as copal, dammar, and kauri are preferred. As a class, they are hard and more or less brittle; the better grades are more or less transparent, and light in color. They fuse with difficulty, and do not readily mix with linseed varnish. This is particularly true of kauri. They are used only in special inks, where a hard glossy finish is necessary, and must be prepared with great care to produce proper results. They do not possess the same tendency to crack as ordinary rosin.

The above substances represent the chief constituents of the oil portion of printing inks. To a very much less extent we may find some of the heavy petroleum oils, vaseline, asphalts, or bituminous products. Sometimes oils other than linseed, having to some extent the property of drying (the so-called semi-drying oils, such as corn oil, nut oil, etc.), are used in an effort to produce a cheaper ink. Chinese wood oil (tung oil) is the only oil which has up to the present time had any measure of success, and there is still much to be learned about it before it may be considered satisfactory. As far as the use of the semi-drying oils to secure cheaper inks is concerned, it must always be considered that a certain amount of quality has been sacrificed to secure a lower price.

Soaps. There is little uniformity in the use of soaps in the manufacture of printing inks. Some manufacturers use scarcely any, while others use considerable quantities. By soap, the metallic salts of fatty and similar organic acids is meant. This would include the common hard and soft soaps (the sodium and potassium salts of the acids from animal and vegetable fats), calcium resinate and oleate, aluminum oleate and palmitate, and the various soaps made from tung oil. The lead and manganese salts of organic acids, while technically soaps, are not considered under this heading because they are used more particularly for the purpose of accelerating the drying of the drying oils in the vehicle.

There is little scientific information available as to the effect of these various soaps on ink compounds. Certain desirable working qualities have been obtained and this is sufficient to justify their use, even though the reason for their action is not known. Among other things it has been suggested that soap acts as a binder between the vehicle and pigment. It would seem as if the entire subject offers a promising field for thorough investigation.

Pigments

Lampblack. Turning now to the pigments, the most important of all is lampblack. This is produced by the burning of oils and fats with an insufficient supply of air for complete combustion. The soot formed is allowed to settle in large chambers, and is collected from time to time. For this burning, lamps are used the construction of which is so controlled as to burn no more carbon than is necessary to keep up the combustion. The temperature of the flame must be kept as low as possible to prevent its burning its own smoke, and more particularly to prevent the distillation of the oil from the lamp. The presence of any considerable quantity of oil in the black will give it a greasy, smeary appearance, and make it totally unfit for further treatment. Various devices have been invented to automatically control the oil supply, so as to avoid loss by evaporation and the consequent spoiling of the black. The use of hollow cylinders through which water is kept running has been found satisfactory. The flame from the lamps strikes the cold metal surface and deposits its soot, which is afterward brushed off and collected.

Lampblack prepared by either of the above processes, when properly carried out, will contain very little oil.

Still another method for the preparation of lampblack is to burn the oil in open pans and draw the soot into a series of chambers. By this method the finest particles, containing very little oil, will collect in the last chambers, while the chambers nearest to the burning oil will collect the heavier particles and most of the evaporated oil. In this way a number of grades of black are prepared in one operation.

It was formerly thought necessary to remove practically all the oil from the lampblack before incorporating the latter in an ink. This is now considered unnecessary and a needless expense. In the case of blacks intended for mixing with linseed varnishes it would probably be desirable to have as little oil as possible, but with those intended for use with mineral and rosin oils the removal of the oil from the black does not seem important enough to warrant the expense of the operation.

Lampblack may contain up to 10 per cent of volatile matter. When heated it gives off a gas or liquid which is usually acid, sometimes neutral, and in rare cases alkaline.

Gas Black. A very different quality of black is prepared by the burning of gas with insufficient air for complete combustion. The soot is deposited on metal cylinders in very much the same way as lampblack from oil. The black produced by this process, known as gas black or carbon black, is practically pure carbon, containing only a trace of oil or volatile matter.

These two pigments, lampblack and gas black, would seem at first glance to be practically the same, and possibly for some purposes the differences between them are of no importance. This is not true when they are used in printing inks. Lampblack, when ground in a soft varnish, gives flow or length to an ink, whereas gas black tends to make the ink short. Lampblack has more opacity and less strength than gas black. There is a great difference in the undertones of the two. It is apparent, therefore, that they are so different in working qualities as to justify the statement that they are in reality two different pigments, each with its own distinctive qualities and uses.

Bone Black. As its name would indicate, bone black is made from charred bones. These are ground until a fine powder is secured. It is evident that such a pigment can never reach the same degree of fineness as lampblack. Its use is confined largely to the plate inks, where its peculiar properties make it a very desirable pigment. Although in thick films it has a very deep black, it lacks strength. It is not a cheap pigment and so can not be considered an adulterant, but it is out of place in the ordinary, or surface, printing inks.

Magnetic Pigment. Still another black pigment used in printing inks is artificial magnetic oxide of iron. This is made by a patented process, which consists essentially in precipitating ferrous salts with alkali, and after partially oxidizing the precipitate, washing and drying it. It has a good color and is quite permanent. There are no data available as to its covering power and strength.

If one were to print with merely a mixture of oil and black pigments, and sufficient ink were carried to mask the undertone of the pigment, the results would be similar, though not identical, for the various blacks. But such heavy inking is not the rule, so that in actual work the ink may be carried so lightly that the effect of the undertone is visible. Furthermore, what the public calls black is in reality a blue-black. Hence an ink maker must compensate for the color of his undertones in order to obtain a denser and purer black. This is accomplished by the use of various blue pigments, such as the iron blues, aniline dyes, or aniline pigments (lakes).

Iron Blues. The iron blues are a mixture of the ferrocyanides and ferricyanides of iron and potassium. The discovery of these pigments dates back to the eighteenth century, when Prussian blue was accidentally discovered by Diesbach, a color manufacturer. It was some years before its true composition was established by chemical research.

When a ferrous or ferric salt is added to potassium ferrocyanide a pigment is precipitated, which, according to the materials used and their purity, will vary in color from a pale blue to a purple. The best known of these pigments is Prussian blue, obtained by adding a ferric salt to potassium ferrocyanide. In commercial practice the pure compound, ferrous ferricyanide — $Fe_7(CN)_{18}$ —, is not obtained, but a mixture of a number of double cyanides. In addition, there seems to be more or less potassium ferrocyanide carried down with the pigment, and, owing to the fact that it is practically impossible to wash it out, it has been considered a part of the pigment.

Iron blues used in the manufacture of printing ink may be classified as follows:

Bronze blue; having a strong bronzy appearance, with a green undertone.

Milori blue; very slight bronzy appearance, with a strong green undertone.

Chinese blue; a deep blue, with strong bronzy appearance and an undertone somewhat like the bronze blue, but inclining more to a red.

Prussian blue; practically no bronzy appearance, with a purple undertone.

These colors are classified more with regard to their color qualities than their chemical composition, the former being of much greater importance, particularly when it is considered that these blues may be used in preparing the chrome greens, when slight differences in color quality will have a marked effect on the green produced.

The iron blues have great tinctorial power and are quite permanent in printing inks. Air, sunlight, and acids do not affect them, but they are completely destroyed by alkalies. This fastness to light gives them great superiority over the aniline pigments, many of which fade very quickly in direct sunlight. It must be remembered, however, that there are a number of blue aniline pigments which are quite permanent to light. It is not uncommon to find both an iron blue and an aniline pigment in black printing ink. The amount of each present will depend largely upon the effect desired.

For the manufacture of colored inks two classes of pigments are used, the natural or artificial mineral pigments, such as vermilion, chrome yellow, ultramarine, etc., and the coal-tar lakes and dyes.

Vermilion. Vermilion is the sulphide of mercury, a brilliant scarlet pigment which seldom occurs in nature in sufficient qualities and pure enough to be used. Most of it is artificially prepared. It is extremely heavy and has good covering power, but a pound of ink made from this pigment will not give as many impressions as a pound of ink made from a lighter pigment of equal strength. This latter fact and its high cost make it too expensive for any but the very best inks. It is used where a brilliant and permanent red is desired.

It is now possible to secure red dyes or lakes which are as fast to light as vermilion, and this fact has materially cut down the use of the latter material. Vermilion is objectionable in that it will rapidly attack a copper electroplate, necessitating the use of nickel in place of the copper. It should never contain free sulphur, since the latter would seriously affect the color of a lead lake should the latter be used in the same ink.

Chrome Yellow. Chrome yellow (lead chromate) is an artificial product prepared by the reaction of a salt of lead (usually the acetate) and sodium or potassium bichromate, or a mixture of the two. It is made in a number of shades varying from a pale canary-yellow through orange to a scarlet. The paler colors always contain more or less lead sulphate, which is precipitated with the pigment and is considered an essential part of it. The orange and scarlet pigments contain varying amounts of basic lead chromate, the deeper shades having the greater amounts of basic chromate.

Chrome yellow pigments are brilliant in tone, dense, with great strength and coloring power, and are considered quite permanent.

Chrome Green. The term "chrome green" is extremely vague. Originally it meant the green oxide of chromium, but the latter is not in very extended use today in printing inks and the name is now generally understood to mean a mixture of chrome yellow with a blue pigment. The latter may be a milori blue, bronze blue, Prussian blue, or Chinese blue, all of them being iron cyanide pigments, all being made in essentially the same way from identical raw materials, but differing somewhat in shade of color. According to which one of these blues is used, the chrome green may be called milori green, bronze green, Brunswick green, etc. The term Brunswick green has also been applied to the oxychloride of copper, but its use in this connection is obsolete. Lead sulphate is present as a constituent of the chrome yellow and aluminum hydrate and precipitated barium sulphate may also be present. Prussian blue is frequently used to produce olive green. The darker shades of green may be made by the addition of varying amounts of black. Chrome green is an excellent color, although not very brilliant in tone. It is quite permanent to light.

Ultramarine. The true ultramarine is the mineral lapis lazuli. This is too rare for practical use. What is commonly known as ultramarine is the artificially prepared pigment, made by heating together china clay, soda, sulphur, and charcoal. The constituents are intimately mixed, finely ground, and heated in an oven. The burning must be carefully controlled. The resultant blue mass is ground, washed free from alkali, and then put through a process of purification in order to get a uniform and satisfactory product.

Ultramarine is apt to be crystalline in nature, and works with difficulty. On account of the sulphur present it can not be used on copper electroplates, and the latter, as in the case of vermilion inks, must be replaced by nickel.

Coal-tar Colors. The coal-tar colors used are too numerous and their manufacture is too detailed an operation to warrant consideration at any length. They cover almost every conceivable color or hue. Many of them are, unfortunately, very fugitive, being easily destroyed by direct sunlight, and such pigments are of value only in work where permanence is not a matter of much importance. There are, however, some coal-tar pigments which are more permanent to light than many inorganic pigments, sufficiently so for any requirements in printing inks.

When an aniline dye is precipitated upon a metallic base a pigment is obtained which is frequently more stable to light than the original dyestuff.

Red Lakes. The red lakes are of such great importance, particularly in the three-color and four-color processes, that without attempting to go into any great detail it seems desirable to present a few facts regarding them.

They are mostly of coal-tar origin and may be roughly divided into three classes, as follows: derivatives of aniline; derivatives of naphthalene; derivatives of anthracene.

The aniline lakes are characterized by their brilliancy of color. They are strong tinctorially, but very fugitive.

The naphthalene lakes are not as bright in color nor as strong tinctorially as the aniline lakes, but they are much more permanent. This class includes the Para colors and the so-called "scarlets."

The anthracene lakes are rather dull in tone and weak tinctorially, but are extremely permanent. The madder and alizarine lakes belong to this class.

There are probably some other organic reds used in printing which are not included in these three classes, but the latter form the largest and most important part.

The choice of lake therefore becomes a matter of what is expected of the finished article. If permanency is of no importance, the aniline lakes would be used on account of their brightness of color, but for record purposes this brilliancy must be sacrificed and the more permanent scarlets, Para reds, madder, and alizarine lakes used.

Driers

There is probably nothing in the manufacture of printing inks which is less understood than the question of driers. Authorities differ on almost every point, and the practical result is that every manufacturer follows his own ideas and the results of his own experience.

We have seen that linseed oil is a drying oil, but in the raw state the drying is a matter of days. Obviously this would not do for printing ink, where we desire a product dry enough to handle in a few hours at the most. Certain metallic bases and salts, principally those of lead and manganese, have the property of accelerating this drying. This property has also been claimed for a variety of materials,[1] but with the exception of the lead, manganese, and possibly cobalt[2] compounds they are practically all useless when not absolutely objectionable.

No definite figures can be given as to the correct amount of drier to use; this must be worked out for each particular case. Some pigments possess considerable drying properties, while others retard drying, and allowance must be made for the amounts of such pigments present in the ink. This is particularly true of the iron blues, which accelerate the drying. In addition, the questions of temperature, atmospheric conditions, quality of paper, speed of press, etc., must each receive due consideration in determining the quantity of drier to be used.

Ink Formulas

It is impracticable to give precise formulas for printing inks; practice varies too greatly. The following will, however, give some slight idea as to the approximate composition of the more common types:

1 See L. E. Andes, "Drying oils, boiled oils," etc., p. 136, for a complete list.

2 Recently cobalt salts, such as the resinate, acetate, and linoleate, have been recommended, and those who have used them report a fair amount of success.

Web-press Inks. For newspaper work the vehicle is usually mineral oil, rosin oil, rosin, and soap, and the pigment is a cheap lampblack with possibly a very small amount of blue dye. For the better grades of web-press inks a thin linseed varnish may replace part of the rosin oil. The pigment will be about 20 per cent of the ink.

Flat-bed Inks. The flat-bed inks are about the same as the better grades of web-press ink, the oil being one-half to two-thirds rosin oil and rosin, the remainder linseed, the latter being a thicker oil than the one used in web-press inks. The pigment will be about 20 to 25 per cent and will consist of a fair grade of lampblack, with Prussian blue or aniline pigments or dyes, and frequently both.

Job Inks. The job inks include many of the colored inks, where, of course, the proportions of vehicle and pigment vary greatly on account of the large differences in specific gravity of the different pigments. If we could express our percentages by volume instead of by weight, these differences would largely disappear. The vehicle should be largely, if not entirely, linseed varnish and hard gums. The pigment, if lampblack, will form about 25 per cent of the ink; for colored inks it may go as high as 60 per cent.

Halftone Inks. Halftone inks are generally used on hard, smooth-surfaced papers. At no time will the penetration of the paper by the ink be very great, and in some cases there will be scarcely any penetration. The vehicle in these inks must be carefully adjusted to the grade of paper. There must always be enough drying oil present so that the ink, although not carried into the paper, will in a very short time set sufficiently to permit of handling the printed sheets without risk of injury. The higher the class of work, the finer the pigment must be to do satisfactory work. Owing to mechanical difficulties a coarse pigment can not be used to produce the finest results. Gas black possesses special advantages over other pigments for this class of work.

Halftone inks require a large amount of pigment, running frequently as high as 30 per cent.

Of course it must be understood that these figures are for inks of good quality. *It should be an axiom with a printer that poor quality is a poor investment at any time.* We have only to pick up a book in which each page has offset on the opposite page, or has some other fault equally objectionable, to realize that the amount saved in poor quality is incommensurate with the loss in value of the finished article.

INK MANUFACTURE

THE first step is the preparation of the vehicle. The oil is boiled or burned by one of the methods described later in the chapter on linseed oil. The rosin, or hard gum, whichever it is proposed to use, is broken into very small pieces and melted over a fire. When the mixture is homogeneous it is added gradually to the hot oil and the whole stirred thoroughly. This is then filtered through a cloth and allowed to stand in order that the smaller particles of dirt, which may have gone through the cloth, may settle. After a few days the clear varnish is drawn from the sediment.

This is, of course, only one of the many methods in use. Sometimes the rosin, in small lumps, is added directly to the oil, which is then stirred until solution is complete, or the oil may be slowly added to the melted gum.

The varnish is now ready for the addition of the pigments. These are first mixed in a mixer, or kneading machine, this part of the process being merely a stirring together of the vehicle and pigments. It does not bring the particles of pigment into as intimate a mixture as is desired. To attain this end the ink, after being in the mixing mill, is ground between rolls, the grinding being repeated until the pigment is thoroughly incorporated with the oil and the grit is entirely eliminated. The cheap inks are ground only once or twice, while the better inks may be ground half a dozen times or more. It is almost impossible to exaggerate the importance of this part of the process; it is the real ink making. Up to a certain point the more thorough the grinding the finer will be the texture and color of the ink. Too much grinding may oxidize the oil, giving it a "heavier body," and thus change the consistency of the ink.

The grinding mill consists of three horizontal rolls which revolve at different speeds, the rear roll slowest, the front roll fastest. The ink from the mixing mill is fed between the rear and middle rolls, and is carried around by the middle to the front roll, where it is scraped off automatically. The differential speed gives the grinding effect and reduces the pigment to the finest division possible.

The rolls used in grinding are of several kinds. Granite rolls are preferred by many; others favor the smooth steel rolls. The grinding develops considerable heat, so that the varnish thins out to some extent. In order to test it properly it is necessary to spread a little on a cold slab, where it will set in a few minutes. Its consistency can then be determined with reasonable accuracy. To overcome this heating, steel rolls, cooled with running water, are used. Advantages and disadvantages are claimed for this method. In its favor it is said that the oil will oxidize less; there is less chance of damaging colored pigments; and the consistency of the ink will be practically the same as it will be when used on the press. On the other hand it is claimed that with a thinner varnish it is possible to grind the ink finer and in less time.

Relation of Ink to Paper

Any discussion of printing ink would be incomplete without some reference to paper. The results obtained depend so much upon the correct adjustment of these two factors that knowledge of one alone will not be sufficient.

For the rapid newspaper or rotary press the paper is fed into the machine in a continuous web. The paper used is a machine-finished printing paper, which receives no further treatment than the slight glazing which it gets on the paper-making machine. It is usually made of wood pulp, with a small amount of rosin sizing, and seldom contains any large amount of added mineral filler. Such a paper has a rough surface and possesses a high degree of absorption. The paper absorbs the ink in very much the same manner as if it were blotting paper; therefore it is not necessary to have any drying oil in the ink.

There is, of course, considerable difference between various makes of this grade of paper. If the fiber has been beaten very fine, or if any amount of filling materials is added, a fairly smooth paper will result, whereas a coarse fiber will give a rough surface. There will be a marked difference between the behavior of these two papers toward the same ink; the rougher one will need more ink on the type to get the same density of color. There will also be a marked difference in the absorption of ink.

One of the first differences noticed between web-press and flat-bed work is the speed at which the presses are run. The latter may occasionally run as high as 2000 to 3000 revolutions an hour, but the usual rate is very much below that. The paper used is either machine-finished printing, or sized and super-calendered.

For book work, if plain text is desired, a machine-finished paper will be used. In composition this paper will vary from all-wood pulp to what is termed "rag machine-finished paper," which may contain as much as 50 per cent rag stock. It is quite the exception to use an all-rag stock for this work.

In books or pamphlets, where illustrations are to accompany the text, the latter is printed on machine-finished paper, and the former on either coated or sized and supercalendered paper.[1] The latter paper has approximately the same composition as the machine-finished, but will contain, in addition to a somewhat larger amount of rosin sizing, about 10 per cent of china clay or some such mineral filler. The smooth surface of this paper is obtained by passing it between heavy rolls, when, under the combined influence of heat and pressure, a glazed surface is obtained. On such paper the ordinary web-press or flat-bed inks will not work satisfactorily, and as a rule a halftone ink, the consistency of which is suitable for this work, is used. The illustrations are inserted during the binding.

The usual method for book printing is to use the machine-finished printing paper with flat-bed ink on the flat-bed press for small editions, and the rotary press with web-press ink for large editions. Where illustrations and text are desired on the same page, a flat-bed press, with sized and supercalendered paper and a halftone ink, is preferred, but this is not absolutely necessary, since good results can be obtained on the rotary press.

Job ink is generally used in printing on paper which is also intended for writing purposes. Such papers are usually made from rag stock, to which has been added, in addition to a certain amount of rosin, a further sizing of glue. Mineral fillers may be present, although as a rule they are not used. In this class of work there is very little absorption of the ink by the paper, and most of the drying effect must come from the ink itself; hence the vehicle should consist largely, if not entirely, of drying oil.

For halftone (or illustration) work, a coated paper is used. The paper itself is of comparatively little

[1] Processes are now being perfected whereby halftone illustrations are successfully printed on ordinary paper.

consequence, and is usually of wood pulp with considerable mineral filler. This is covered with a mixture of china clay and casein and, when dry, is glazed, the resulting surface being absolutely smooth. Such a surface is necessary in order that it may receive the impression from even the finest lines of the halftone plates. The ink remains on the surface entirely, and the varnish used must dry within 16 to 24 hours — i.e., overnight — so as to permit of safe handling the following day.

Necessity for Proper Grades of Paper

It will be seen that each grade of ink is prepared to give satisfaction with a particular grade of paper. To secure the best results with any ink it should be used on the paper for which it is intended, and, furthermore, the paper itself must be of good quality. This, of course, refers only to cases where it is desired that the work to be turned out shall be of good quality, have a good appearance, and be more or less permanent; there is always a certain amount of work where almost anything will do, if it does not cost too much. If it is admitted that a poor ink will not work satisfactorily on any grade of paper, it must also be seen that a poor grade of paper will not work satisfactorily with any ink. A short ink (one having slight cohesion) will not give good results, no matter what sort of press or paper is used, unless the pressman stands by and keeps constantly pushing it up against the feed roll. Similarly, a paper with loose fibers would be constantly filling up the type, and in such cases the trouble would not be with the ink being too tacky but in the paper. It is evident that one factor depends on the other, and neither can be neglected with impunity.

It is not within the scope of this treatise to deal with the testing of paper, but simply to point out the necessity of being sure that the quality of the paper is all that it should be and suited to the work on hand. This is so obvious that a single illustration will be sufficient to show its importance.

During the printing of some halftone illustrations at the Government Printing Office it was noticed that some of the sheets had a streaked appearance, which rendered them unfit for use. The trouble was at first supposed to be due to an inferior ink, but examination proved that the latter was satisfactory and all that could be expected. The examination of the paper was not so satisfactory. Small pit holes, visible only under the microscope, could be seen wherever there was a streak. They were probably caused by minute bubbles of gas in the coating mixture, and their occurrence in streaks was probably due to the action of the brushes in the coating machine. Whatever the cause, it was a problem for the paper manufacturer to solve. Difficulties with paper such as this might occur at any time and would probably not be noticed in the ordinary examination of the paper.

The point to remember in this connection is that trouble, when it does occur, is not always due to faulty ink. The paper is frequently at fault and will bear investigation. This is assuming that there are only two causes for trouble, ink and paper. It might be well to remember that presses, and even pressmen, are not always blameless.

Opacity of Inks

The question of the opacity of inks is always one of importance. According to the use to which the ink is to be put, it may be dense and opaque, or it may be translucent.

For ordinary printing on white paper it is desirable to have the ink as opaque as possible, since the ink does not need to be carried as heavily on the type to get a satisfactory impression. If, however, one is printing with a colored ink on colored paper, then opacity is of the greatest importance, since the color of the ink will be materially changed if the color of the paper shows through it.

With the three-color and four-color processes the reverse is true. The three-color process consists of printing in red, yellow, and blue, obtaining the intermediate or secondary colors by printing one color on another. The four-color process adds black to the three colors above mentioned. The first color printed may be opaque without affecting the results seriously, but the other impressions must be as translucent as possible.

With these facts in mind, it will be seen that an ink which is suitable for multicolor processes is not suitable for printing one color on a colored paper. The reverse is equally true, except as above noted, when the opaque ink is used for the first impression.

WHAT CONSTITUTES A GOOD INK

THE question is frequently asked: What constitutes a good ink? To answer it correctly, one should know exactly for what purpose the ink is intended. This problem has received considerable attention at the Government Printing Office at Washington, and a set of requirements and tests for the various inks used there has been formulated. These are so comprehensive as to be worth printing in full.

INK REQUIREMENTS OF THE GOVERNMENT PRINTING OFFICE

Requirements for a Satisfactory Test

WEB-PRESS INK

1. Nonseparation of Oil from Pigment — The oil or varnish should not separate from the pigment either on the face of the type or in the fountain.

2. Transfer — Ink should transfer from type to paper so as to leave face of type clean.

3. Tack — Ink should have sufficient "tack" to dry rapidly, but should not pull the nap or face from the paper, nor the face from the roller.

4. Drying — Ink should not dry on form, rollers, or distribution so that it may not be easily removable therefrom after standing overnight.

5. Spreading of Oil or Varnish — The oil or varnish should not spread in the paper after printing.

6. Color — The ink must dry a bright, solid *black*, not gray; it should not blister the face of the paper, and should dry rapidly enough to permit quickly handling of printed product.

7. Quantity Required — The weight of the amount used must be noted and averaged on a basis of 10000 printed pages.

JOB BLACK INK

1. Nonseparation of Oil from Pigment — The oil or varnish should not separate from the pigment either on the face of the type

or plates or in the fountain, but should be short enough to break up readily in the distribution and not "string."

2. TRANSFER — Ink should transfer from type or plates to paper so as to leave the face of type or plates reasonably clean.

3. TACK — Ink should dry hard on writing or bond paper to admit of easy handling at the press without damage or injury to the work, and should not pull the coating or face from the paper, nor the face from the roller.

4. DRYING — Ink should not dry on form, rollers, or distribution so that it may not be easily removed therefrom.

5. OFFSET OR SMUTTING — Must be able to carry sufficient color, print clean and sharp, without offset or smut on sheets falling on top from the press fly, or in piling the work; nor should the offset pile up on the draw sheet in backing up.

6. COLOR — The ink must dry a deep, solid carbon (not aniline) black, and not turn gray nor have a metallic sheen or luster, nor blister the face of the paper.

7. QUANTITY REQUIRED — The weight of the amount used must be noted and averaged on a basis of 5000 printed pages.

FLAT-BED BLACK INK

1. NONSEPARATION OF OIL FROM PIGMENT — The oil or varnish should not separate from the pigment either on the face of the type or cuts or in the fountain, but should be short enough to break up readily in the distribution and not "string."

2. TRANSFER — Ink should transfer from type or cuts to paper so as to leave the face of type or cuts reasonably clean.

3. TACK — Ink should dry hard on the machine-finished paper immediately to admit of easy handling without damage or injury to the work, and should not pull the coating or face from the paper, nor the face from the roller, nor blister the face of the paper.

4. DRYING — Ink should not dry on form, rollers, or distribution so that it may not be easily removed therefrom.

5. OFFSET OR SMUTTING — Must be able to carry sufficient color, print clean and sharp, without offset or smut on the tympan when printing the second or reverse side of the sheet.

6. COLOR — The ink must dry a deep, solid carbon (not aniline) black, and not turn gray.

7. QUANTITY REQUIRED — The weight of the amount used must be noted and averaged on a basis of 5000 printed pages.

HALFTONE BLACK INK

1. NONSEPARATION OF OIL FROM PIGMENT — The oil or varnish should not separate from the pigment either on the face of the type

or cuts or in the fountain, but should be short enough to break up readily in the distribution and not "string."

2. TRANSFER — Ink should transfer from type or cuts to paper so as to leave the face of type or cuts reasonably clean.

3. TACK — Ink should dry hard on the paper in eight hours to admit of easy handling without damage or injury to the work, and should not pull the coating or face from the paper, nor the face from the roller.

4. DRYING — Ink should not dry on form, rollers, or distribution so that it may not be easily removed therefrom.

5. OFFSET OR SMUTTING — Must be able to carry sufficient color, print clean and sharp, without offset or smut on sheets falling on top from the press fly, or in piling the work.

6. COLOR — The ink must dry a deep, solid carbon (not aniline) black, and not turn gray nor have a metallic sheen or luster, nor blister the face of the paper.

7. QUANTITY REQUIRED — The weight of the amount used must be noted and averaged on a basis of 5000 printed pages.

METHODS TO BE USED IN PRACTICAL TESTS

WEB-PRESS INK

The practical test of web-press ink shall be made on the web presses in use in the Government Printing Office.

The test shall be made on machine-finished book paper of the size, weight, and quality in general use in the Government Printing Office.

The type forms or plate forms shall be previously "made ready" and the press otherwise in good condition to make a satisfactory run.

The form, rollers, distribution, and ink fountain shall then be thoroughly washed and cleaned. The ink to be tested shall be weighed before being placed in the fountain. The quantity to be tested should be sufficient to run not less than three hours, and preferably a five-hour run will be made.

The press, form, rollers, and distribution will be permitted to stand overnight unwashed, in order to observe the drying on the face of the form, the rollers, and the distribution.

Ink that will separate the oil or varnish from the pigment on face of type or in the fountain will not be accepted.

Ink to be satisfactory should, under the impress, transfer from the face of the type to the paper, leaving the face of the type clean. It should have sufficient "tack" to dry rapidly, but must not pull the nap or face from the paper and leave it on the face of the type, or pull the face from the rollers. It should be easily removed from the type, rollers, and distribution after standing overnight. It should not contain oil or varnish which will spread in the paper after printing.

The ink to be satisfactory must dry a bright, solid black, and not turn gray or blister the face of the paper.

After the test has been made, the remaining quantity of ink shall be removed from the fountain and weighed, a reasonable allowance being made for the ink necessarily left in the fountain, on the rollers and distribution, in order to determine the number of copies a given quantity of the ink will print.

JOB BLACK INK

The practical test of job black ink shall be made on the flat-bed presses in the Government Printing Office.

The test shall be made on book, writing, and bond paper of the size, weight, and quality in general use in the Government Printing Office.

The type or plate forms shall be previously "made ready" and the press otherwise in good condition to make a satisfactory run.

The form, rollers, distribution, and ink fountain shall then be thoroughly washed and cleaned. The ink to be tested shall be weighed before being placed in the fountain. The quantity to be tested should be sufficient to run not less than three hours, and preferably a run of five hours will be made.

Ink that will separate the oil or varnish from the pigment on face of form or in the fountain will not be accepted.

Ink to be satisfactory should, under the impression, transfer from the face of the type or plates to the paper, leaving the face of the type or plates reasonably clean. It should be heavy in body and feed well; it should have sufficient "tack" to dry rapidly enough on the paper while printing to avoid the necessity of using slip-sheets, but it should dry hard on the paper quickly, so that the work can be easily handled without damage or injury to the printing. It must not pull the face or coating from the paper and leave it on the face of the form, or pull the face from the rollers. It should be easily removed from the form, rollers, and distribution; must be able to carry sufficient color without offset or smut, and print clean and sharp.

The ink to be satisfactory must dry a deep, solid carbon (not aniline) black, and not turn gray, nor have a metallic sheen or luster, nor blister the face of the paper.

After the test has been made, the remaining quantity of ink shall be removed from the fountain and weighed, a reasonable allowance being made for the ink necessarily left in the fountain, on the rollers and distribution, in order to determine the number of copies a given quantity of ink will print.

FLAT-BED BLACK INK

The practical test of flat-bed black ink shall be made on the flat-bed presses in the Government Printing Office.

The test shall be made on machine-finished book paper of the size, weight, and quality in general use in the Government Printing Office.

The type or cut forms shall be previously "made ready" and the press otherwise in good condition to make a satisfactory run.

The form, rollers, distribution, and ink fountain shall then be thoroughly washed and cleaned. The ink to be tested shall be weighed before being placed in the fountain. The quantity to be tested should be sufficient to run not less than three hours, and preferably a run of five hours will be made.

Ink that will separate the oil or varnish from the pigment on face of form or in the fountain will not be accepted.

Ink to be satisfactory should, under the impression, transfer from the face of the type to the paper, leaving the face of the type reasonably clean. It should be heavy in body and feed well; it should have sufficient "tack" to dry rapidly, so that the work can be easily handled immediately without damage or injury to the printing. It must not pull the face from the paper and leave it on the face of the form, or pull the face from the rollers. It should be easily removed from the form, rollers, and distribution; must be able to carry sufficient color without offset or smut on the tympan when printing the second or reverse side of the sheets, and print clean and sharp.

The ink to be satisfactory must dry a deep, solid carbon (not aniline) black, and not turn gray, nor blister the face of the paper.

After the test has been made, the remaining quantity of ink shall be removed from the fountain and weighed, a reasonable allowance being made for the ink necessarily left in the fountain, on the rollers and distribution, in order to determine the number of copies a given quantity of ink will print.

HALFTONE BLACK INK

The practical test of halftone black ink shall be made on the flat-bed presses in use in the Government Printing Office.

The test shall be made on coated book paper of the size, weight, and quality in general use in the Government Printing Office.

The type or cut forms shall be previously "made ready" and the press otherwise in good condition to make a satisfactory run.

The form, rollers, distribution, and ink fountain shall then be thoroughly washed and cleaned. The ink to be tested shall be weighed before being placed in the fountain. The quantity to be tested should be sufficient to run not less than three hours, and preferably a run of five hours will be made.

Ink that will separate the oil or varnish from the pigment on face of form or in the fountain will not be accepted.

Ink to be satisfactory should, under the impression, transfer from the face of the type or cuts to the paper, leaving the face of the type or cuts reasonably clean. It should be heavy in body, feed well, and have the consistency of new butter; it should have sufficient "tack" to dry rapidly enough on the paper while printing to avoid the necessity of using slip-sheets, but it should dry hard on the paper in eight hours, so that the work can be easily handled without damage or injury to the printing. It must not pull the face or coating from the paper and leave it on the face of the form, or pull the face from the rollers. It should be easily removed from the form, rollers, and distribution; must be able to carry sufficient color without offset or smut, and print clean and sharp.

The ink to be satisfactory must dry a deep, solid carbon (not aniline) black, and not turn gray, nor have a metallic sheen or luster, nor blister the face of the paper.

After the test has been made, the remaining quantity of ink shall be removed from the fountain and weighed, a reasonable allowance being made for the ink necessarily left in the fountain, on the rollers and distribution, in order to determine the number of copies a given quantity of ink will print.

These requirements and tests are, of course, ideals, which are not always fulfilled in practice, yet it is the unanimous opinion of the pressmen of the Government Printing Office that if they could secure inks which measured up to these standards there could be no cause for dissatisfaction.

There is some explanation which might be made of these tests. In rating an ink for "tack" it should be remembered that an ink can be poor by reason of too much or too little tackiness, and one defect is about as bad as the other. It should always be stated in which direction the trouble lies. The same is true of the drying; it should be specifically stated whether the ink is not drying rapidly enough, or if the fault is in the opposite direction, such as drying on the rolls, distribution, etc. A case is reported where a pressman stated repeatedly that the tack was poor, but gave no further explanation, and before the manufacturer was finally aware of the nature of the trouble he was producing an ink with the tackiness of glue.

The requirements for tack in test No. 3 state how rapidly the ink must "dry." Some printers and ink manufacturers use the term "set" in this connection, reserving the term "drying" for the final hardening of the ink. This explanation will probably suffice to prevent misunderstanding.

The ideal ink, one which will be satisfactory under any and all circumstances, does not exist, and probably never will. The mere fact that so many different inks are made should suffice to prove that the experience of the printers and ink makers has shown the necessity for suiting the ink to the paper. Since this is the case, it is obviously to the advantage of all for the printer to keep his ink maker informed as to the paper upon which the ink is to be used. This is particularly true of the small lots made up for special jobs. Coöperation along these lines would be of great advantage in eliminating trouble, saving time, labor, material, etc.

It might not be out of place to remark that no printer should ever try to improve upon his ink in order to remedy a fault. He should endeavor, in the first place, to buy an ink suited to his work. If the ink purchased is unsatisfactory the ink maker should be compelled to deliver the proper grade of ink, or point out that the ink ordered is not suited to the work in hand.

Tinkering with an ink, such as the adding of glycerin or vaseline to make it work better, should be resorted to only under exceptional circumstances, and whenever it is done the ink should be absolved from any trouble which may be caused by these "improvements." It is far better to have a variety of inks at hand, sufficient for any contingency that may arise, than to make one ink fulfill the purposes of many.

MANUFACTURE AND TESTING OF LINSEED OIL

THE United States is not only the largest manufacturer and consumer of linseed oil, but is second in the production of flaxseed, being surpassed in this latter respect only by the Argentine Republic.

The first step in the manufacture of linseed oil is grinding the seed. The latter is fed into the top of a stand of rolls, usually five in number, the pressure used being simply that of the weight of the rolls, and as the seed descends it is subjected to a constantly increasing pressure which crushes it into a fine meal. The ground seed is then tempered; that is, heated for some time in a closed kettle, steam being admitted from time to time to maintain the necessary amount of moisture in the seed. If the seed is very old and dry it may even be necessary to add water.

The tempered meal is then formed into cakes, and these are placed in a press and subjected to hydraulic pressure of approximately 600 pounds to the square inch. After this pressure has extracted about all the oil that it can, the pressure is increased to about 3800 pounds. The total time for pressing is usually somewhat less than an hour. The pressed oil is run off in wooden troughs to the receiving tanks.

Linseed oil, as it comes from the press, contains a large amount of sediment, or "foots," which must be entirely removed if the oil is to be used for making printing-ink varnishes. For painting, the complete removal of foots is not so important, although the quantity should be reduced to the lowest practicable limit. Filter pressing the oil after it has cooled will remove a considerable amount of foots, and then storing the oil for some time in settling tanks will remove most of the remainder and give a comparatively clear oil.

If it is not desired to wait for this settling process, rapid methods may be used to refine the oil. Sulphuric acid is one of the most commonly used agents, the differences between the various methods being principally in the manner of removing the acid after the refining and bleaching are accomplished. The complete removal of the mineral acid is obligatory. When a light-colored varnish is desired, the raw oil must be practically neutral. Neutralizing the organic acidity of the oil with alkali, and then filter pressing, will give a clear neutral oil. These rapid processes for refining linseed oil all have a more or less injurious effect on its quality, and experience has shown that a well-settled oil is to be preferred.

Several new processes for extracting linseed oil from the seed have been developed, consisting essentially in removing the oil from the seed by means of certain solvents, such as naphtha, carbon bisulphide, etc., the solvent being distilled off from the oil, condensed, and used for further extraction. The loss of solvent by this method is very slight, and the resultant oil is of very good quality and comparatively free from foots. Some oils are practically ready for immediate use for varnish making. The fire risk seems to be one of the greatest hindrances to the extension of this process. The use of noncombustible solvents, such as carbon tetrachloride, is being tried, with some measure of success.

Linseed oil has the property of combining with the oxygen of the air, on exposure in thin layers, the final result being the formation of a hard film. The oil is changed into linoxyn, and the process is termed "drying." The rate of the drying may be increased by any of the following methods: Mechanical treatment of the oil, aging of the oil, raising of the temperature, exposure to sunlight, and addition of certain driers.

From a technical point of view the most important of these methods is the use of driers, the product being known as boiled oil. The oil is heated and stirred to thoroughly remove the moisture; the drier (containing usually compounds of lead and manganese) is introduced and the two are thoroughly mixed. The oil is kept at a high temperature for some time after the addition of the drier, although the longer the oil is heated the darker it becomes. When the process is deemed complete the oil is cooled and filtered through filter presses, the result being a dark, mobile oil which will, when exposed to the air in thin films, dry in about 24 hours. This oil is not used to any great extent in ink manufacture.

Raw linseed oil, or boiled oil, when placed on a clean sheet of paper will instantly sink into the paper, leaving a greasy stain. The oil must therefore be so changed that such penetration will not take place. There are two processes for accomplishing this, boiling and burning. The raw material is neutral raw linseed oil, free from metallic driers.

The boiling process for making linseed varnish consists in heating the oil in a tall cylindrical kettle, which is sometimes provided with a wide flange or basin on the side to prevent the oil, should it froth over, from reaching the fire. A tight-fitting cover is also provided, and the whole so arranged as to be quickly and easily removable from the fire. In some cases the kettle is stationary and the fire removed from under the kettle. The oil must be heated until a sample withdrawn from the kettle shows, upon cooling, that it has reached the desired consistency.

The temperature must be carefully regulated. Each kettle is provided with a thermometer, and the variation in temperature is kept as low as possible. The usual temperature is about 575° F (302° C). The time varies greatly with different raw oils, so that no definite time of heating can be specified. About ten grades of varnish are made by this process, from No. 0000, a very thin varnish, to No. 7, which has the viscosity of molasses. These varnishes are used in making the ordinary printing inks. The thinner oils are used in inks for fast work, such as web-press inks, while the thicker oils are used in the job and halftone inks, which are used on the slower presses. It is seldom that an ink is made from a single varnish; to get the desired working qualities it may be necessary to use two or more.

The loss in oil by this boiling process is very small. If a clear, neutral oil has been used, a light-colored product will be obtained. However, the color of the oil is of little importance if the ink made is black.

The other method for preparing linseed varnish — burning — is practically the process first used in making printing inks. Oil is heated in small open kettles and then ignited. It is allowed to burn, with constant stirring, until the desired consistency is reached. A strong draft must be provided to carry off the fumes and soot produced by the burning. The loss during the burning is considerable, being from 5 per cent up. There are not so many grades of varnish made by this process, five being the usual number.

Burnt oils are usually called plate oils, because they are used almost exclusively in the preparation of engraver's ink. In the engraving process the plate is inked and the excess of ink is wiped off. In order that the plate shall be clean it is necessary for the ink to have but slight cohesion, or be "short." Stringing, or length, is objectionable. Varnishes made by the burning method are much shorter than those prepared by boiling, hence their use in engraving ink.

HELPFUL INFORMATION ABOUT THE USE OF PRINTING INKS

BY

PHILIP RUXTON

HELPFUL INFORMATION ABOUT THE USE OF PRINTING INKS

THE following suggestions apply to some of the daily uses of printing inks, and are experiences that have come under the notice of the writer from day to day covering a period of years of ink difficulties and successes.

Inks for Job Presses. Inks for job and platen presses should be of a little stiffer consistency than those for a cylinder press. There is more tendency for the dot to spread under the platen method of printing than under that of the cylinder impression. The stiffer consistency of the ink makes it lay better. In ordering ink, state whether it is to be used for a platen or a cylinder press.

Getting the Press Clean. There are probably more complaints of unsuccessful matches of inks on account of improper wash-ups than from other causes. If black ink has been on the press previous to the use of a delicate color or tint, even with one or two wash-ups, the black residue which remains will slightly change the tint or the shade of the color. It sometimes requires three or four wash-ups to remove all the black. The slightest amount of black will change any tint. Pressmen frequently put white ink on a press first, when a tint is going to be run, and wash-up two or three times in this ink. Care should be exercised not to have any dust or oil on the ends of the rollers, as there is a tendency for this to work in and affect the tint.

Changing Printing Inks. It is undesirable for the average pressman to change the character of inks that are well made, as it invites trouble and disappointment. Putting in oils or greases of inferior quality is dangerous. Mixing an ink of one grade with another is also undesirable. While there are instances of success, the general result is poor, and when it results in disaster the ink man is unfairly blamed.

Mixing Colors and Tints. (*a*) First get a piece of plate glass or a marble slab big enough to hold the quantities you require for your average work, together with two palette knives. It is also desirable to have a pair of scales if you hope to obtain accurate results. (*b*) In mixing tints always start with the light color, darkening it with the strong one you are to use. A very small quantity of a strong color will make a tint, even in proportion of one to fifty. If you work with the strong color first you will find that when you want five pounds you will often get ten. (*c*) Have plenty of mixing white on hand to reduce colors. (*d*) To make a color light, add white. Some colors can be safely darkened with black, but black must be used with care, as it is liable to change the hue as well as the shade. To gray a color, add its opposite, or complement; for instance, to gray a yellow add a small amount of blue purple, and similarly with the other complements.

For red add a little blue green
For red purple add a little green
For purple add a little green yellow
For purple blue add a little yellow
For blue add a little yellow red

(*e*) It is desirable that these colors be of about the same strength because if one color is much stronger than its opposite the stronger color will prevail when used in equal parts. (*f*) Should one color be twice as strong as its opposite, use only one half as much to get a neutral gray.

Printing Tints with Black. The practice of recent years has shown that the best results come from printing the black first and then using a transparent color over it. The method gives better register and there is less necessity for slip-sheeting, for when the black is printed over the tint the black does not go into the paper as it does when it is printed under the tint impression. Furthermore, when a black vignetted edge is printed over a tint the tint plate does not clean the ink from the black plate as well as the paper does, and thus causes the ink to gather on the edge of the vignette and makes a blemish on the printing.

Reducing Tints. Reduce tints with a thin varnish. Should the color appear mottled, add a little flake white to give it body. The addition of magnesia will also prevent mottling, but this should be added only when the tint is a solid or near-solid. When magnesia is added and the ink used for halftone work there is a tendency for it to fill the screen.

Transparent Colors. Most ink makers manufacture colors in a transparent base, so that the lighter colors can be printed last, printing the key plate in a darker color first. This aids in the register and the pressman can see how each form is running. These inks are a little more expensive than the regular inks. Most process inks are now made in a transparent base. In ordering inks state whether they are to be used as transparent colors.

Ink for Making-ready. On all forms where much time is required for making-ready see that a soft ink is used, as a stiff ink, such as is used to run a good halftone form, will dry hard on the rollers while the press waits. The soft ink prints well enough to mark out your sheet. When you are ready to go ahead put on the right ink and you will find that your troubles are greatly lessened by having fresh ink.

Enamel Paper Variation. The paper maker cannot deliver an enamel paper, order after order, with exactly the same surface; and if one month the coating is a little weak the ink which did not pick last month is bound to lift the surface of the weaker paper. Coatings for enamel paper contain glue, clay, blanc fixe, satin white, etc., each manufacturer having special secret formulas of his own. In the first two items there is a great chance for variation. The price of glue varies greatly, the domestic grades being much cheaper than the imported. Just how much increasing the price would mean increasing the quality would be hard for any one not a practical paper manufacturer to say. Clay is a general name given to impure varieties of aluminum silicate, and ordinary clay often contains calcium carbonate, magnesium carbonate, and iron hydroxids. The purest form of clay found in nature is kaolin, and from native clay to the choicest imported there is a wide range of price and quality. In England the fixe clay is found almost exclusively in Cornwall. Blanc fixe is artificial barium sulphate, and satin white an artificial white pigment consisting of a mixture of calcium sulphate and aluminum hydroxid. When you consider that these ingredients, as well as others, are mixed in various proportions, and competition is making a constant demand for a satisfactory coating at a low cost, it is no wonder that the printer occasionally has trouble fitting his inks to a given stock. The writer has noticed during extremely cold weather many instances where the coating of the stock seemed to "powder off," and the "softest" inks would pick. Thus it is obvious that the printer should not always ascribe his troubles to "the ink not being the same as the last."

Picking of Halftone Inks. This is caused by several things, such as a cold pressroom, a poor surface coated paper, too much tack in the ink, etc. The best method is to have a thin black ink, ground very fine, with no tack whatever. This may be added to your strong ink and will remove the tack without changing the color. In an emergency the addition of thin varnish or boiled linseed oil will do.

The usual method of "fixing" a halftone black, which on a cold morning is picking the enamel, is to reduce it by about 10% to 15% with No. 00 varnish. This causes the color to crawl on the edges of the cuts, and kills the life of the ink. The principal ingredients of halftone black are varnish and the black coloring matter, the varnish being graded according to its tack or strength. Halftone black is usually ground in a medium varnish, and carries all the black pigment it will stand, and if the pressman adds more varnish he destroys the color, for varnish in itself is practically colorless, and the more varnish you add the more you reduce the blackness. Therefore we recommend the mixing of a stiff and a soft ink to the required consistency, rather than using varnish as a reducer.

Do not use boiled oil in process inks, as it is a drier and is likely to cause crystallization. The manufacturer of the ink should be consulted.

Use of Driers. Driers are very essential in every pressroom, as the drying quality of an ink is affected by the temperature, and it is impossible to make an ink that will dry equally well on all kinds of paper. A printer should have two kinds of drier, one that penetrates the stock and one that dries by the action of the air. For example, if you have a hard stock, like a bond paper, use an air drier, as there is no chance for the paper to absorb the ink, which must necessarily dry on the surface of the stock. On a coated or soft paper use the penetrating drier, which will take the ink into the stock and dry it there. It will then set quickly, avoiding offset in many instances, if a proper make-ready is used and only the necessary amount of ink carried.

Printing on High Finish Enamel Cards. It is always difficult to make an ink lie well on this kind of stock. To make it print well, add a little copal varnish. Should this make it pick, add a small amount of reducer.

Drying on Rollers. When ink dries too quickly on the rollers, add a reducer such as can be purchased from any ink maker for this purpose, or change for an ink in which the drier is omitted. When a small form is running the ink on the ends of the rollers tends to dry, as this portion of them is not coming into contact with the form. Under these conditions there is a possibility that the rollers will crack at the ends. The remedy is to put a few drops of machine oil on the ends of the rollers. If it is desired to keep the ink without reducing or other doctoring, the remedy for too fast drying on rollers is to wash off frequently and thus keep the supply of ink fresh. This is advisable for good work.

Amount of Color to Carry. It is possible to change the color of an ink by the amount carried on the rollers. A thin film of ink makes the color very light and a heavy film gives a much darker appearance, so much so sometimes that it appears to be another color. The reason for this is that on the thin film printing the paper shows through, while on the heavy film the paper is entirely covered. Apparently, on the thin film print the paper is covered, but such is not the case. If you look at it under a powerful magnifying glass you will see that the paper shows through, thus demonstrating that the paper is full of little hills and hollows. When an ink appears mottled it is probable that too much color is being carried. If it is necessary to carry a large amount of ink to get the color it is better to darken the ink and carry less color, thus eliminating the mottle.

Too Much Color. It is a common fault among young pressmen to print a job with too much color, letting the color take the place of proper make-ready. As a pressman improves in his work he discovers that, if he is careful in his make-ready and sees to it that every type and dot that the typesetter and engraver intended to show is printing, he can carry a minimum of ink, thus avoiding the tendency to fill up, mottle, and offset.

Waste of Ink by Skinning. All printing inks have a tendency toward drying or skinning. When you open a can of ink do not take a knife and dig down in the center, but carefully remove the paper disc and take from the surface all the ink you will need. Then cover the ink again with the paper disc or put in a new one. You will save much ink in this way.

Drying Chalky Inks. Some inks rub off the paper after the ink dries. This means that the varnish is separating from the pigment, leaving the pigment on the surface. This can be remedied by the use of a liquid or paste drier. Usually half an ounce of drier to a pound of ink is sufficient. The paper is often responsible for this trouble.

Sheets Sticking Together. It is often the case that sheets carrying a full amount of color or one color over another have a tendency to stick together when piled. This can be obviated by adding a little melted paraffin to the ink, not over a quarter of an ounce of paraffin to five pounds of ink. Castor oil may also be used, but it tends to make the ink dry slower and is not as effective as the paraffin.

Preventing Inks from Rubbing off Enamel Surfaces. Add a small amount of gold size to the ink, not over one ounce to a pound, and the color will dry hard on the enamel surface.

Gold Ink. This is a difficult ink to run. The best results are obtained by the use of a prepared varnish or size. This is mixed with the bronze in the fountain, about half-and-half. If, on running, it is discovered that the form can carry more bronze, it may be added, or vice versa, more size if there is too much bronze. To make a heavy ink, i.e., one with a greater proportion of bronze than varnish: First, ink up the press. Let the press run for a few minutes and work this paste-like ink into the rollers. It will be found upon starting the run with the thinner ink (in equal proportion) that better results will be obtained than when the heavy ink is put on at once.

Gold Bronze. This is applied by first printing a gold size (which is of a yellow color) on the paper. The bronze is then applied with a bronzing machine, or with a wad of cotton held in the hand and dipped into the supply of bronze, finally spreading it over the printed sheet. The bronze adheres to the printed part and the surplus is rubbed off. The sheets are then dusted with a clean wad of cotton. Beautiful effects are obtained with various shades of bronze. When the printing is embossed it heightens the luster and adds much to the appearance. Catalog covers treated in this manner are most effective.

Printing Solids. Here more color is always required than on type forms. Carry all the color possible without mottling. There are instances when the ink is better for printing solids if it is reduced. However, if a good luster is desired this is not practicable. If the ink "cakes" on the plates a little heavy varnish (#6) added to the ink will overcome the difficulty. This will cause the ink to become more "tacky" and it will therefore adhere more readily to the paper, thus cleaning the form at each impression. Sometimes it is desirable to add a little reducer to the stiff varnish. The judicious use of the two opposites gives a good result.

Ink and Paper. A knowledge of the relation of ink and paper is desirable for all pressmen. Ink will print differently on different kinds of paper. An ink which prints well on machine-finish paper may mottle on coated. The ink men can make an ink for every kind of paper. It is desirable, however, for the pressman to have this knowledge of the different papers so that he will know how to meet the various conditions that may arise. It is foolish to waste good ink on cheap paper when the cheaper ink would print better.

Copying Inks. This ink is used in printing way-bill blanks which are used in copying books. It is troublesome, as it tends to affect the rollers. It is a good idea to have a special set of rollers for an occasional job of this nature and to have them pretty hard. Wash the press and rollers carefully with lye and rinse with water — warm water if convenient.

Cover Inks. Inks of this kind are made up in stiff varnish and are very strong in color. In printing solids and large areas of ordinary cover stock one printing is enough, but if the stock is very rough and absorbent, two impressions are required and sometimes three. It is quite impossible to print fine type lines and have them look well on cover stock. Adding body gum or varnish to cover ink will give it a luster, and make the form print sharp and clean. Gold bronzes always look well on dark cover stock. Embossing of any color on cover stocks greatly improves the work.

Doubletone Inks. Beautiful effects are obtained from these inks, especially in the art shades of browns and greens. The undertoning caused by the stains in the ink produce a photographic effect, especially on dull finished papers, which is very desirable. Care must be used in printing these inks, for if too much color is carried the undertoning is too strong. Many jobs are ruined on this account. It is always desirable to slip-sheet work printed with these inks.

Dull Inks. These inks have been developed in recent years. Their splendid pastel qualities have created a large demand and they are being used on commercial and illustrated catalog work. They have little tack and are very easy working and are especially suitable for dull papers. They seldom require slip-sheeting. To get the proper effect more color should be carried on a form when using dull ink than when regular varnish inks are employed.

Dullopaque Inks. These kinds of dull inks are made in various shades for fine catalog printing and art work. They are made only in "art" shades and are principally used on dull papers. The slight undertoning is very effective. The inks are easy working and lay smooth on the paper, giving a good mat surface. Where there are solid backgrounds they are especially effective.

The Right Red with Black. Much is said about the right red to use with black. Of course, it makes some difference how strong the face of the type is, also how much white paper shows. For the normal page, however, a red toward the orange, almost a pure vermilion, is right. As vermilion affects type and electrotypes, most ink makers have made this color in a lake base, thus eliminating the above trouble. Many jobs are spoiled by the inexperienced through using a red toward blue or pink.

Process Inks. Process inks are made in four colors: Yellow, red, blue, and black. Most ink houses make several yellows, varying from a greenish yellow to a chrome; several reds, from a pink to a bluish red; and several blues, from a peacock to a dark blue. These varieties are to meet the demand of the engravers who seem to have different standards of colors. With these colors almost any result can be obtained. The greens and purples in a picture are affected most because it is difficult to get a fine green by the use of yellow and blue. It is also difficult to get a good purple by the use of red and blue.

In printing the halftone dots of the three-color plate, the dots, being in close juxtaposition, give the effect of several colors, grays and soft tints. It is highly important that all the colors "take" on the paper, as well as that one color prints over the other in a proper manner, for if they do not much of the quality is lost. Progressive proofs are generally furnished by engravers for the pressman to follow. Generally the yellow prints first, red second, blue third, and black last. In large runs, where close register is required, the black is sometimes run first, so that the pressman may have a guide for the register of the other colors. When the black is printed first the colors following, especially the yellow, should be transparent. Process colors are generally timed to run a day apart. Should one of the colors crystallize it will be necessary to add oversize to the next color to make it adhere properly. Many jobs are spoiled by one ink not "taking" on the other.

Wet-printing Process Inks. Wet printing, so called, is the laying of several colors over each other in quick succession. Some presses at present are made to print two, three, or four colors at one operation. There are a few presses that print as high as six. The principle which makes this possible is that the second color is weaker in tack than the first one, and so on with each succeeding color; in other words, the first color printed has the strongest tack and each succeeding color has less tack. This form of printing requires much care on the part of the ink maker and also on the part of the printer. The least error brings much trouble. However, many large concerns are producing creditable work. The results suffer quite a little in sharpness, as the colors have a slight tendency to assimilate. There is little question but that the next few years will see this process of printing nearly perfected. Of course, it is necessary for the ink maker to know the order of the printing of each color in order to get good results. Should the yellow, which is generally printed first, not be tacky enough to pull off the red (printed second), the yellow should be made more tacky or the red less so. However, the first way is the better. It is generally necessary to slip-sheet wet printing as the volume of color of three or more colors is so great that there is much offset. Any color can be made in wet printing inks and the ingredients in their manufacture are the same as those in ordinary inks.

Ink Record Book. It is desirable to keep a record of the ink used on all important jobs. Take a good sized scrap book, paste in all samples of jobs when finished, together with the ink record of the job, how much ink it took to the thousand, how many copies were printed, how the job ran, and what difficulties were encountered with the ink or paper. This will prove valuable, as the months go on, in making estimates. It is surprising how far off some pressmen are in their estimates of the quantity of ink required for a given job. There are probably few places in a printing office where there is a greater variation of opinion than in ink estimates.

Keep Can Labels Clean. Large amounts of ink are annually wasted because the labels on the containers have become dirty and are unreadable. Make it a rule to always keep the container labels clean, so that they may be quickly read. In some shops it is a rule that ink cans must not be handled with dirty hands, or ink smeared on the outside. It is a simple matter to hold the ink can with a piece of paper in the hand. This will help to keep the label clean.

SUPPLEMENTARY READING

INKS

Chemistry and Technology of Printing Inks. By Norman Underwood and Thomas V. Sullivan. D. Van Nostrand Co., New York, 1915.

Practical Printing. By George Sherman. Oswald Publishing Co., New York, 1911.

The Manufacture of Ink. By Sigmund Lehner; translation by Wm. T. Brannt. Henry Carey Baird & Co., Philadelphia, 1892.

Inks, Their Composition and Manufacture. By C. A. Mitchell and T. S. Hepworth. Charles Griffin & Co., Ltd., London, 1904.

Oil Colors and Printers' Ink. By Louis E. Andes. D. Van Nostrand Co., New York, 1903.

Modern Printing Inks. By Alfred Seymour. Scott, Greenwood & Son, London, 1910.

The American Manual of Presswork. Oswald Publishing Co., New York, 1911.

Lectures on Printing Ink. By James A. Ullman. The Sigmund Ullman Co., New York, 1911.

The Relation of the Printer to the Ink Maker. By Robert H. Hochstetter. Michigan Printers' Cost Commission, 1914.

OILS

Printers' Colors, Oils, and Varnish. By George H. Hurst. Charles Griffin & Co., Ltd., London, 1901.
Linseed Oil and Other Seed Oils. By William D. Ennis. D. Van Nostrand Co., New York, 1909.
Drying Oils, Boiled Oils, Etc. By Louis E. Andes. Scott, Greenwood & Co., London, 1901.
Solvents, Oils, Gums, Waxes, and Allied Substances. By Frederick Sackett Hyde. D. Van Nostrand Co., New York, 1913.
Chemistry of the Oil Industries. By James Edward Southcombe. Constable & Co., Ltd., London, 1913.

PIGMENTS

The Manufacture of Lake Pigments from Artificial Colors. By Francis H. Jennisen. Scott, Greenwood & Co., London, 1900.
The Chemistry of Pigments. By E. J. Parry and J. H. Coste. Scott, Greenwood & Co., London, 1902.
Modern Pigments and Their Vehicles. By Frederick Maire. J. Wiley & Sons, New York, 1908.
Analysis of Mixed Paints, Color Pigments, and Varnishes. By Holley & Ladd. J. Wiley & Sons, New York, 1908.

SUGGESTIONS TO STUDENTS AND INSTRUCTORS

THE following questions, based on the contents of this pamphlet, are intended to serve (1) as a guide to the study of the text, (2) as an aid to the student in putting the information contained into definite statements without actually memorizing the text, (3) as a means of securing from the student a reproduction of the information in his own words.

A careful following of the questions by the reader will insure full acquaintance with every part of the text, avoiding the accidental omission of what might be of value. These primers are so condensed that nothing should be omitted.

In teaching from these books it is very important that these questions and such others as may occur to the teacher, should be made the basis of frequent written work, and of final examinations.

The importance of written work cannot be overstated. It not only assures knowledge of material but the power to express that knowledge correctly and in good form.

If this written work can be submitted to the teacher in printed form it will be doubly useful.

QUESTIONS

1. What are the two ingredients of all printing ink?
2. Why has the ink in many of the earliest books retained its color?
3. Upon what does the durability of a printed page depend?
4. Why has the ink in some early books offset on the opposite page?
5. How did the early printers get their ink?
6. What caused ink making to become an independent industry?
7. What qualities had to be developed in ink?
8. What is the difference between "long" and "short" ink?
9. What was the difference between early English and Dutch inks?
10. What is meant by "varnish" in the printing ink trade?
11. How was varnish originally made?
12. What changes took place in the eighteenth and nineteenth centuries, and why?

13. What four general classes of ink are now made?
14. Give the peculiarities of each, and tell what each is used for.
15. What is linseed oil, and what are its properties?
16. What are semidrying oils and for what are they used?
17. What is Chinese wood oil?
18. What is rosin, and what is its use in ink making?
19. What is rosin oil, and what is it used for?
20. What can you say of the value of rosin oil in ink manufacture?
21. What are some of the hard gums used by ink makers and what are they used for?
22. What other substances are used in the oil part of printing ink?
23. What is the most important of the pigments?
24. Give various methods for manufacturing it.
25. Is it necessary to remove all the oil from this substance, and why?
26. What is gas black, and how is it made?
27. What is bone black, and how is it made?
28. What is magnetic pigment, and how is it made?
29. How does the ink maker obtain a dense, pure black, and why?
30. What are iron blues, and how are they made?
31. Name and describe the four most important iron blues.
32. What are the qualities of the iron blues?
33. What classes of pigments are used in the manufacture of colored inks?
34. What is vermilion and what are its qualities?
35. What is chrome yellow and what are its qualities?
36. What is chrome green and what are its qualities?
37. How are the green shades produced?
38. What is ultramarine, and what are its qualities?
39. What can you say of the coal-tar colors?

40. What are the red lakes, and what are their qualities?
41. Name and describe three of the principal red lakes.
42. How would you decide which of the lakes should be used in any particular job?
43. What substances are used to hasten the drying of ink?
44. How can the proper amount of drier be determined?
45. Give the approximate composition of each of the four kinds of ink referred to in question 13.
46. Describe the process of ink manufacture.
47. What sort of paper is used for newspapers, for flat-bed work, for book work, and for illustrations?
48. What sorts of paper and ink are used for paper which is to be written on as well as printed on?
49. What sort of paper is used for halftones?
50. When is an opaque ink desirable, and when not?
51. How can the best results be obtained from any ink?
52. Give the United States Government Printing Office requirements and tell how the tests are made for

    a. Web-press ink.
    b. Job black ink.
    c. Flat-bed black ink.
    d. Halftone black ink.

53. What would you do if the ink you were using was not working well?
54. Describe the manufacture of linseed oil.
55. What peculiar property has linseed oil, and how may this property be increased?
56. Describe the most important of these methods.
57. What happens when raw linseed oil is placed on a clean sheet of paper?
58. What processes are used for preventing this?

59. What is the difference between ink for a platen press and ink for a cylinder press?
60. What should be done when a colored ink, especially a pale one, is to be used after a run of black?
61. Is it advisable to try to change the character of ink, and why?
62. Describe the process of mixing colors to get tints.
63. How can you make a color light or dark?
64. How can you make a color gray? Give some examples.
65. How can you get the best results in printing tints with black?
66. How can you reduce tints?
67. What are transparent colors, and how are they used?
68. How is ink managed in forms where considerable time is needed for making-ready?
69. How are coated papers made and what causes variation of their surfaces?
70. What are the causes of picking in halftone inks, and how can it be remedied?
71. What is the best method of reducing halftone ink, and why is it better than others you can name?
72. What two kinds of driers are there, and when should each be used?
73. What can be done to secure good printing on high enamel cards?
74. What can be done when ink dries on the rollers?
75. What is a remedy when ink dries too quickly on the rollers in running work on which it is not advisable to change or doctor the ink?
76. What effects are produced by varying the amount of color carried?
77. What happens when too much color is carried, and what is the remedy?

78. How can waste of ink by skinning be prevented?
79. What causes chalkiness in ink, and how can it be prevented?
80. What causes printed sheets to stick together, and how can it be prevented?
81. How can ink be prevented from rubbing off enameled surfaces?
82. How is gold ink handled?
83. How is bronze powder handled?
84. What is done to get good results in printing solids?
85. What can you say of the relation of ink to paper?
86. What are copying inks and how are they run?
87. What are the peculiarities of cover inks, and how are they used?
88 What precautions are needed in using doubletone inks?
89. What are the characteristics of dull inks and how are they used?
90. What are the peculiarities of dullopaque inks, and what are their uses?
91. What reds should and what should not be used with black?
92. In what colors are process inks made?
93. What should be looked out for in printing three-color plates?
94. What order of colors is generally followed in color process printing?
95. What is the usual interval between color printings?
96. What can be done if one color does not lie properly on another?
97. What is wet printing?
98. How is it done, and what is required for success?
99. What is the nature and value of an ink record book?
100. Describe an easy method to keep ink labels clean.

This volume contains many chemical terms. When these terms are used simply as the names of commercial substances, which may be bought under these names in the open market, they are not defined. When these terms are used in a technical or descriptive sense an attempt has been made to define them sufficiently to give the apprentice a general idea of what the substances are without attempting to go into the science of chemistry.

ALIZARINE — A peculiar red coloring matter originally produced from madder, but now extensively manufactured from anthracene. See Madder and Anthracene.

ANILINE DYES — Colors produced by the combination of various chemicals with aniline, a product obtained from coal tar. These dyes come in a great variety of colors, many of them very beautiful, but they are liable to be unstable.

ANTHRACENE — A coal-tar product, obtained by distillation and pressure. It consists of white, crystalline flakes, and is especially valuable as a base for alizarine.

CASEIN — One of the chief ingredients of milk, and the principal constituent of cheese. Dissolved in a strong solution of borax it forms an excellent glue.

CYANIDE — A combination of cyanogen (nitrogen and carbon in combination) and a metallic base, as cyanide of potassium.

FERRIC — Pertaining to or extracted from iron. In the ferric compounds iron always enters as two atoms. See Ferrous.

FERRICYANIDE — A compound of a base with ferri-cyanogen (cyanogen and a form of iron).

FERROCYANIDE — A compound of a base with ferro-cyanogen (cyanogen and a form of iron different from that in ferricyanogen).

FERROUS — Pertaining to, or derived from, iron. In the ferrous compounds iron always enters as a single atom. See Ferric.

GILSONITE — A very pure form of asphalt, found in Utah.

HOMOGENEOUS — Composed of similar parts or elements: opposed to heterogeneous, compound of dissimilar parts or elements.

HUMIDITY — Dampness, commonly said of the air: the amount of dampness in the air, relative to the temperature, affects paper and many other things.

LAKE — A pigment formed by absorbing animal, vegetable, or coal-tar coloring matter from a solution in water by means of a metallic base. A very great variety of colors is thus made.

LITHARGE — An oxide of lead. An oxide is a combination of oxygen and some other substance.

MADDER — A plant found in India and parts of Asia and Africa, and a dye or pigment obtained from it.

MULLER STONES — Stones for grinding paints and pigments.

Naphthalene — One of the coal-tar products. Base of an important group of colors.

Offset — The transfer of superfluous or undried ink to the opposite page.

Opaque — Not permitting the passage of light. See Translucent and Transparent.

Organic — Pertaining to the animal and vegetable world.

Oxidation — The process of combination of any substance with oxygen.

Oxychloride — A combination of a metallic chloride (combination of chlorine and a metal) with oxygen.

Pick — Said of ink when it sticks to the paper and picks off bits of the surface or bits of the ink film itself.

Pigment — Any substance which can be used by makers of paint or ink to produce color when mixed with the proper oil, varnish, or other vehicle.

Slip-sheeting — Placing blank sheets between printed sheets when piled up fresh from the press in order to prevent offsetting or smutting.

Spatula — A broad flat blade or strip of metal or wood with unsharpened edges and commonly a rounded outer end and a handle.

Sulphate — A salt of sulphuric acid.

Sulphide — A combination of sulphur with other substances having certain characteristics.

Tack — Stickiness, as of a painted, varnished, oiled, or inked surface partly dried.

Translucent — Permitting the passage of light partially.

Transparent — Permitting the passage of light fully and freely. See Opaque and Translucent.

Undertone — The color of a pigment when seen in very thin layers on a white surface: a tone of color seen through and giving character to other colors.

TYPOGRAPHIC TECHNICAL SERIES FOR APPRENTICES

THE following list of publications, comprising the TYPOGRAPHIC TECHNICAL SERIES FOR APPRENTICES, has been prepared under the supervision of the Committee on Education of the United Typothetae of America for use in trade classes, in courses of printing instruction, and by individuals.

Each publication has been compiled by a competent author or group of authors, and carefully edited, the purpose being to provide the printers of the United States—employers, journeymen, and apprentices—with a comprehensive series of handy and inexpensive compendiums of reliable, up-to-date information upon the various branches and specialties of the printing craft, all arranged in orderly fashion for progressive study.

The publications of the series are of uniform size, 5 x 8 inches. Their general make-up, in typography, illustrations, etc., has been, as far as practicable, kept in harmony throughout. A brief synopsis of the particular contents and other chief features of each volume will be found under each title in the following list.

Each topic is treated in a concise manner, the aim being to embody in each publication as completely as possible all the rudimentary information and essential facts necessary to an understanding of the subject. Care has been taken to make all statements accurate and clear, with the purpose of bringing essential information within the understanding of beginners in the different fields of study. Wherever practicable, simple and well-defined drawings and illustrations have been used to assist in giving additional clearness to the text.

In order that the pamphlets may be of the greatest possible help for use in trade-school classes and for self-instruction, each title is accompanied by a list of Review Questions covering essential items of the subject matter. A short Glossary of technical terms belonging to the subject or department treated is also added to many of the books.

These are the Official Text-books of the United Typothetae of America.

Address all orders and inquiries to COMMITTEE ON EDUCATION, UNITED TYPOTHETAE OF AMERICA, CHICAGO, ILLINOIS, U. S. A.

PART I—*Types, Tools, Machines, and Materials*

1. **Type: a Primer of Information** . By A. A. Stewart
Relating to the mechanical features of printing types; their sizes, font schemes, etc., with a brief description of their manufacture. 44 pp.; illustrated; 74 review questions; glossary.

2. **Compositors' Tools and Materials** By A. A. Stewart
A primer of information about composing sticks, galleys, leads, brass rules, cutting and mitering machines, etc. 47 pp.; illustrated; 50 review questions; glossary.

3. **Type Cases, Composing Room Furniture** By A. A. Stewart
A primer of information about type cases, work stands, cabinets, case racks, galley racks, standing galleys, etc. 43 pp.; illustrated; 33 review questions; glossary.

4. **Imposing Tables and Lock-up Appliances** By A. A. Stewart
Describing the tools and materials used in locking up forms for the press, including some modern utilities for special purposes. 59 pp.; illustrated; 70 review questions; glossary.

5. **Proof Presses** . . . . . By A. A. Stewart
A primer of information about the customary methods and machines for taking printers' proofs. 40 pp.; illustrated; 41 review questions; glossary.

6. **Platen Printing Presses** . . . By Daniel Baker
A primer of information regarding the history and mechanical construction of platen printing presses, from the original hand press to the modern job press, to which is added a chapter on automatic presses of small size. 51 pp.; illustrated; 49 review questions; glossary.

7. **Cylinder Printing Presses** . . By Herbert L. Baker
Being a study of the mechanism and operation of the principal types of cylinder printing machines. 64 pp.; illustrated; 47 review questions; glossary.

8. **Mechanical Feeders and Folders** By William E. Spurrier
The history and operation of modern feeding and folding machines; with hints on their care and adjustments. Illustrated; review questions; glossary.

9. **Power for Machinery in Printing Houses** By Carl F. Scott
A treatise on the methods of applying power to printing presses and allied machinery, with particular reference to electric drive. 53 pp.; illustrated; 69 review questions; glossary.

10. **Paper Cutting Machines** . . . By Niel Gray, Jr.
A primer of information about paper and card trimmers, hand-lever cutters, power cutters, and other automatic machines for cutting paper. 70 pp.; illustrated; 115 review questions; glossary.

11. **Printers' Rollers** . . . . . By A. A. Stewart
A primer of information about the composition, manufacture, and care of inking rollers. 46 pp.; illustrated; 61 review questions; glossary.

12. **Printing Inks** . . . . . . By Philip Ruxton
Their composition, properties and manufacture (reprinted by permission from Circular No. 53, United States Bureau of Standards); together with some helpful suggestions about the everyday use of printing inks by Philip Ruxton. 80 pp.; 100 review questions; glossary.

PART I (continued)—*Paper and Printing Plates*

13. **How Paper is Made** . By William Bond Wheelwright
A primer of information about the materials and processes of manufacturing paper for printing and writing. 68 pp.; illustrated; 62 review questions; glossary.

14. **Relief Engravings** . . . .
Brief history and non-technical description of modern methods of engraving: woodcut, zinc plate, halftone; kind of copy for reproduction; things to remember when ordering engravings. Illustrated; review questions; glossary.

15. **Electrotyping and Stereotyping**
By Harris B. Hatch and A. A. Stewart
A primer of information about the processes of electrotyping and stereotyping. 94 pp.; illustrated; 129 review questions; glossaries.

PART II—*Hand and Machine Composition*

16. **Typesetting** . . . . . By A. A. Stewart
A handbook for beginners, giving information about justifying, spacing, correcting, and other matters relating to typesetting. Illustrated; review questions; glossary.

17. **Printers' Proofs** . . . . By A. A. Stewart
The methods by which they are made, marked, and corrected, with observations on proofreading. Illustrated; review questions; glossary.

18. **First Steps in Job Composition** . By Camille DeVèze
Suggestions for the apprentice compositor in setting his first jobs, especially about the important little things which go to make good display in typography. 63 pp.; examples; 55 review questions; glossary.

19. **General Job Composition** . . .
How the job compositor handles business stationery, programs and miscellaneous work. Illustrated; review questions; glossary.

20. **Book Composition** . . . By J. W. Bothwell
Chapters from DeVinne's "Modern Methods of Book Composition," revised and arranged for this series of text-books by J. W. Bothwell of The DeVinne Press, New York. Part I: Composition of pages. Part II: Imposition of pages. 229 pp.; illustrated; 525 review questions; glossary.

21. **Tabular Composition** . . . By Robert Seaver
A study of the elementary forms of table composition, with examples of more difficult composition. 86 pp.; examples; 45 review questions.

22. **Applied Arithmetic** . . . . By E. E. Sheldon
Elementary arithmetic applied to problems of the printing trade, calculation of materials, paper weights and sizes, with standard tables and rules for computation, each subject amplified with examples and exercises. 159 pp.

23. **Typecasting and Composing Machines** A. W. Finlay, Editor
Section I—The Linotype . . . . By L. A. Hornstein
Section II—The Monotype . . . . By Joseph Hays
Section III—The Intertype . . . . By Henry W. Cozzens
Section IV—Other Typecasting and Typesetting Machines . . By Frank H. Smith
A brief history of typesetting machines, with descriptions of their mechanical principles and operations. Illustrated; review questions; glossary.

PART III—*Imposition and Stonework*

24. **Locking Forms for the Job Press** By Frank S. Henry
Things the apprentice should know about locking up small forms, and about general work on the stone. Illustrated; review questions; glossary.

25. **Preparing Forms for the Cylinder Press** By Frank S. Henry
Pamphlet and catalog imposition; margins; fold marks, etc. Methods of handling type forms and electrotype forms. Illustrated; review questions; glossary.

PART IV—*Presswork*

26. **Making Ready on Platen Presses** By T. G. McGrew
The essential parts of a press and their functions; distinctive features of commonly used machines. Preparing the tympan, regulating the impression, underlaying and overlaying, setting gauges, and other details explained. Illustrated; review questions; glossary.

27. **Cylinder Presswork** . . . By T. G. McGrew
Preparing the press; adjustment of bed and cylinder, form rollers, ink fountain, grippers and delivery systems. Underlaying and overlaying; modern overlay methods. Illustrated; review questions; glossary.

28. **Pressroom Hints and Helps** . By Charles L. Dunton
Describing some practical methods of pressroom work, with directions and useful information relating to a variety of printing-press problems. 87 pp.; 176 review questions.

29. **Reproductive Processes of the Graphic Arts** By A. W. Elson
A primer of information about the distinctive features of the relief, the intaglio, and the planographic processes of printing. 84 pp.; illustrated; 100 review questions; glossary.

PART V—*Pamphlet and Book Binding*

30. **Pamphlet Binding** . . . By Bancroft L. Goodwin
A primer of information about the various operations employed in binding pamphlets and other work in the bindery. Illustrated; review questions; glossary.

31. **Book Binding** . . . . . By John J. Pleger
Practical information about the usual operations in binding books: folding, gathering, collating, sewing, forwarding, finishing. Case making and cased-in books. Hand work and machine work. Job and blank-book binding. Illustrated; review questions; glossary.

PART VI—*Correct Literary Composition*

32. **Word Study and English Grammar** By F. W. Hamilton
A primer of information about words, their relations, and their uses. 68 pp.; 84 review questions; glossary.

33. **Punctuation** . . . . . . By F. W. Hamilton
A primer of information about the marks of punctuation and their use, both grammatically and typographically. 56 pp.; 59 review questions; glossary.

PART VI (continued)—*Correct Literary Composition*

34. **Capitals** . . . . . . By F. W. Hamilton
A primer of information about capitalization, with some practical typographic hints as to the use of capitals. 48 pp.; 92 review questions; glossary.

35. **Division of Words** . . . . By F. W. Hamilton
Rules for the division of words at the ends of lines, with remarks on spelling, syllabication and pronunciation. 42 pp.; 70 review questions.

36. **Compound Words** . . . . By F. W. Hamilton
A study of the principles of compounding, the components of compounds, and the use of the hyphen. 34 pp.; 62 review questions.

37. **Abbreviations and Signs** . . . By F. W. Hamilton
A primer of information about abbreviations and signs, with classified lists of those in most common use. 58 pp ; 32 review questions.

38. **The Uses of Italic** . . . . By F. W. Hamilton
A primer of information about the history and uses of italic letters. 31 pp.; 37 review questions.

39. **Proofreading** . . . . . By Arnold Levitas
The technical phases of the proofreader's work; reading, marking, revising, etc.; methods of handling proofs and copy. Illustrated by examples. 59 pp.; 69 review questions; glossary.

40. **Preparation of Printers' Copy** . . By F. W. Hamilton
Suggestions for authors, editors, and all who are engaged in preparing copy for the composing room. 36 pp.; 67 review questions.

41. **Printers' Manual of Style** . .
A reference compilation of approved rules, usages, and suggestions relating to uniformity in punctuation, capitalization, abbreviations, numerals, and kindred features of composition.

42. **The Printer's Dictionary** . . By A. A. Stewart
A handbook of definitions and miscellaneous information about various processes of printing, alphabetically arranged. Technical terms explained. Illustrated.

PART VII—*Design, Color, and Lettering*

43. **Applied Design for Printers** . . By Harry L. Gage
A handbook of the principles of arrangement, with brief comment on the periods of design which have most influenced printing. Treats of harmony, balance, proportion, and rhythm; motion; symmetry and variety; ornament, esthetic and symbolic. 37 illustrations; 46 review questions; glossary; bibliography.

44. **Elements of Typographic Design** . By Harry L. Gage
Applications of the principles of decorative design. Building material of typography: paper, types, ink, decorations and illustrations. Handling of shapes. Design of complete book, treating each part. Design of commercial forms and single units Illustrations; review questions; glossary; bibliography.

PART VII (continued)—*Design, Color, and Lettering*

45. **Rudiments of Color in Printing** . By Harry L. Gage

Use of color: for decoration of black and white, for broad poster effect, in combinations of two, three, or more printings with process engravings. Scientific nature of color, physical and chemical. Terms in which color may be discussed: hue, value, intensity. Diagrams in color, scales and combinations. Color theory of process engraving. Experiments with color. Illustrations in full color, and on various papers. Review questions; glossary; bibliography.

46. **Lettering in Typography** . . By Harry L. Gage

Printer's use of lettering: adaptability and decorative effect. Development of historic writing and lettering and its influence on type design. Classification of general forms in lettering. Application of design to lettering. Drawing for reproduction. Fully illustrated; review questions; glossary; bibliography.

47. **Typographic Design in Advertising** By Harry L. Gage

The printer's function in advertising. Precepts upon which advertising is based. Printer's analysis of his copy. Emphasis, legibility, attention, color. Method of studying advertising typography. Illustrations; review questions; glossary; bibliography

48. **Making Dummies and Layouts** . By Harry L. Gage

A layout: the architectural plan. A dummy: the imitation of a proposed final effect. Use of dummy in sales work. Use of layout. Function of layout man. Binding schemes for dummies. Dummy envelopes. Illustrations; review questions; glossary; bibliography.

PART VIII—*History of Printing*

49. **Books Before Typography** . . By F. W. Hamilton

A primer of information about the invention of the alphabet and the history of bookmaking up to the invention of movable types. 62 pp.; illustrated; 64 review questions.

50. **The Invention of Typography** . By F. W. Hamilton

A brief sketch of the invention of printing and how it came about. 64 pp.; 62 review questions.

51. **History of Printing**—Part I . . By F. W. Hamilton

A primer of information about the beginnings of printing, the development of the book, the development of printers' materials, and the work of the great pioneers. 63 pp.; 55 review questions.

52. **History of Printing**—Part II . . By F. W. Hamilton

A brief sketch of the economic conditions of the printing industry from 1450 to 1789, including government regulations, censorship, internal conditions and industrial relations. 94 pp.; 128 review questions.

53. **Printing in England** . . . By F. W. Hamilton

A short history of printing in England from Caxton to the present time. 89 pp.; 65 review questions.

54. **Printing in America** . . . By F. W. Hamilton

A brief sketch of the development of the newspaper, and some notes on publishers who have especially contributed to printing. 98 pp.; 84 review questions.

55. **Type and Presses in America** . By F. W. Hamilton

A brief historical sketch of the development of type casting and press building in the United States. 52 pp.; 61 review questions.

PART IX—*Cost Finding and Accounting*

56. **Elements of Cost in Printing** . . By Henry P. Porter
A primer of information about all the elements that contribute to the cost of printing and their relation to each other. Review questions. Glossary.

57. **Use of a Cost System** . . . By Henry P. Porter
The Standard Cost-Finding Forms and their uses. What they should show. How to utilize the information they give. Review questions. Glossary.

58. **The Printer as a Merchant** . . By Henry P. Porter
The selection and purchase of materials and supplies for printing. The relation of the cost of raw material and the selling price of the finished product. Review questions. Glossary.

59. **Fundamental Principles of Estimating** By Henry P. Porter
The estimator and his work; forms to use; general rules for estimating. Review questions. Glossary.

60. **Estimating and Selling** . . . By Henry P. Porter
An insight into the methods used in making estimates, and their relation to selling. Review questions. Glossary.

61. **Accounting for Printers** . . . By Henry P. Porter
A brief outline of an accounting system for printers; necessary books and accessory records. Review questions. Glossary.

PART X—*Miscellaneous*

62. **Health, Sanitation, and Safety** . . By Henry P. Porter
Hygiene in the printing trade; a study of conditions old and new; practical suggestions for improvement; protective appliances and rules for safety.

63. **Topical Index** . . . . . By F. W. Hamilton
A book of reference covering the topics treated in the Typographic Technical Series, alphabetically arranged.

64. **Courses of Study** . . . By F. W. Hamilton
A guidebook for teachers, with outlines and suggestions for classroom and shop work.

ACKNOWLEDGMENT

THIS series of Typographic Text-books is the result of the splendid co-operation of a large number of firms and individuals engaged in the printing business and its allied industries in the United States of America.

The Committee on Education of the United Typothetae of America, under whose auspices the books have been prepared and published, acknowledges its indebtedness for the generous assistance rendered by the many authors, printers, and others identified with this work.

While due acknowledgment is made on the title and copyright pages of those contributing to each book, the Committee nevertheless felt that a group list of co-operating firms would be of interest.

The following list is not complete, as it includes only those who have co-operated in the production of a portion of the volumes, constituting the first printing. As soon as the entire list of books comprising the Typographic Technical Series has been completed (which the Committee hopes will be at an early date), the full list will be printed in each volume.

The Committee also desires to acknowledge its indebtedness to the many subscribers to this Series who have patiently awaited its publication.

COMMITTEE ON EDUCATION,
UNITED TYPOTHETAE OF AMERICA.

HENRY P. PORTER, *Chairman*,
E. LAWRENCE FELL,
A. M. GLOSSBRENNER,
J. CLYDE OSWALD,
TOBY RUBOVITS.

FREDERICK W. HAMILTON, *Education Director*.

CONTRIBUTORS

For Composition and Electrotypes

Isaac H. Blanchard Company, New York, N.Y.
S. H. Burbank & Co., Philadelphia, Pa.
J. S. Cushing & Co., Norwood, Mass.
The DeVinne Press, New York, N. Y.
R. R. Donnelley & Sons Co., Chicago, Ill.
Geo. H. Ellis Co., Boston, Mass.
Evans-Winter-Hebb, Detroit, Mich.
Franklin Printing Company, Philadelphia, Pa.
F. H. Gilson Company, Boston, Mass.
Stephen Greene & Co., Philadelphia, Pa.
W. F. Hall Printing Co., Chicago, Ill.
J. B. Lippincott Co., Philadelphia, Pa.
McCalla & Co. Inc., Philadelphia, Pa.
The Patteson Press, New York.
The Plimpton Press, Norwood, Mass.
Poole Bros., Chicago, Ill.
Edward Stern & Co., Philadelphia, Pa.
The Stone Printing & Mfg. Co., Roanoke, Va.
C. D. Traphagen, Lincoln, Neb.
The University Press, Cambridge, Mass.

For Composition

Boston Typothetae School of Printing, Boston, Mass.
William F. Fell Co., Philadelphia, Pa.
The Kalkhoff Company, New York, N.Y.
Oxford-Print, Boston, Mass.
Toby Rubovits, Chicago, Ill.

For Electrotypes

Blomgren Brothers Co., Chicago, Ill.
Flower Steel Electrotyping Co., New York, N.Y.
C. J. Peters & Son Co., Boston, Mass.
Royal Electrotype Co., Philadelphia, Pa.
H. C. Whitcomb & Co., Boston, Mass.

For Engravings

American Type Founders Co., Boston, Mass.
C. B. Cottrell & Sons Co., Westerly, R. I.
Golding Manufacturing Co., Franklin, Mass.
Harvard University, Cambridge, Mass.
Inland Printer Co., Chicago, Ill.
Lanston Monotype Machine Company, Philadelphia, Pa.
Mergenthaler Linotype Company, New York, N.Y.
Geo. H. Morrill Co., Norwood, Mass.
Oswald Publishing Co., New York, N.Y.
The Printing Art, Cambridge, Mass.
B. D. Rising Paper Company, Housatonic, Mass.
The Vandercook Press, Chicago, Ill.

For Book Paper

American Writing Paper Co., Holyoke, Mass.
West Virginia Pulp & Paper Co., Mechanicville, N.Y.