MODERN PRINTING INKS

A. SEYMOUR

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A PRACTICAL HANDBOOK FOR PRINTING INK MANUFACTURERS AND PRINTERS

BY

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PREFACE.

This little volume is intended, as its title indicates, to be used as a handbook by manufacturers and users of printing inks. Its utility to the manufacturer should be assured by the fact that it has been written by a practical man for practical men. The author has a thorough knowledge of his subject, and it is hoped that the fruits of his experience are here set forth with sufficient clearness to be of service to any one requiring a text-book or work of reference dealing with these industries. The book is specially designed to help the working printer to become better acquainted with a material which he uses every day—and sometimes with very unsatisfactory results. It is becoming more and more apparent that those who carry out each particular industrial process should understand the scientific basis on which every such process ultimately rests. A printer who takes the trouble to learn what the materials of his craft consist of, and how they are prepared, will be able to handle them in a far more intelligent and efficient manner than one who in his self-satisfied ignorance trusts merely to "old use and wont" or simple rule of thumb. Printers' Ink is a commodity the production and use of which are rapidly increasing, and an encouraging welcome for this small contribution to the literature of the subject is confidently anticipated by

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CHAPTER I.

INTRODUCTION.

Division of Labour—A Separate Industry—Choice of Materials—Skilful Manipulation—Some Important Factors—The Medium—Ink and Colour Mixing—A Justification.

It has frequently been asserted, and with some degree of truth, that division of labour in industrial life is so shrewdly planned and apportioned that workmen are only a little better than machines. However that may be, in some crafts division of labour has many redeeming qualities. In the printing trades the old-time systems were far from unmixed blessings, and division of labour has certainly proved to be a lesser evil; moreover, its introduction has been to a great extent unavoidable. The manufacture of printing inks affords an excellent proof of these statements, for modern developments in printing compelled the adoption of some more elastic and more economical arrangement of the work, and both the parent craft and its offspring have benefited thereby. In the early days of typography and lithography the printers prepared their own varnishes and inks, though not always in the Arcadian manner described by a continental writer who states: "On fine days the printing office staff went out into the garden or the fields and rigged up their boiling-pot. Then the assistants had a festival culminating in roasting bread in the hot linseed oil and eating it."

The requirements of modern printing have since created a separate industry for the manufacture of printing inks, the growth of which has been more or less compulsory. Yet although the development of this industry has been chiefly along well-defined lines, indicated by the demands of the craft with which it is indissolubly associated, there has been no lack of initiative, consequently the manufacture of printing inks includes an ever-extending range of interests which must of necessity receive ample consideration in a descriptive text-book. It has long ago passed its period of secret formulæ and practices, that is if it ever really had such a period. The secret of success in this, as in many other phases of work, is a felicitous combination of the requisite materials. The manufacture of modern printing inks requires an intelligent and consistent consideration of at least three points. First, a careful choice of materials; second, their skilful manipulation; and last, but by no means of lesser importance, their suitable application.

Choice of materials is one of the most influential factors in the preparation of printing inks. A full description of the essential materials has been carefully compiled and included in this work, so that the craftsman may better understand their value and make his selection accordingly. Many compositions which are but little known in association with printing inks, and therefore but rarely used, are also described. A knowledge of their characteristics may in some way prove useful. Skilful manipulation is also emphasised by practical examples of its value and influence, while the importance of suitable application is again and again demonstrated by explanations of causes and their effects, which, by the way, there is frequently a dangerous tendency to underestimate. The progressive developments of modern printing, and especially of colour printing, have compelled the printing ink makers to meet the many exacting requirements which, from time to time, have been created. In the endeavours to satisfy these requirements a great variety of material has been introduced, and an almost bewildering diversity of colours. The speed at which modern printing machines are worked, the quality and character of the paper printed upon, the many different processes in operation, and the colour effects which are frequently sought after, are all important factors in the determination of essential qualities in printing inks. So important are these factors that the printing ink maker must give individual consideration to each one of them. It is obvious, therefore, that anything approaching inflexible working standards in the preparation of printing inks would be difficult to arrange, and even more difficult to maintain; *e.g.*, a black ink may be required to print a half-tone photo-engraving on a fine paper and at a high speed, or for printing a heavy, solid impression on a soft fluffy paper of ordinary quality. Then again a pigment may be needed for lithographic or letterpress printing, for quick or slow drying, or, in fact, to meet any peculiar conditions of the work or circumstances. Every requirement must receive independent consideration as the occasion may arise.

These few examples will in a measure explain the consistent attention which must be given to the manufacture of printing inks.

The medium or vehicle in which the colouring materials and bases of printing inks are ground is a varnish prepared from linseed oil. This medium or varnish must possess certain characteristics which can best be secured from linseed oil. A short descriptive chapter on "Linseed Oil" has therefore been included in this volume, so that as a text-book it may be self-contained. Should the reader feel disposed to carry his investigations further in this direction, he will find a wealth of information in an excellent and exhaustive treatise, *Drying Oils, Boiled Oils*, etc., by Louis E. Andés (Scott, Greenwood & Son), and also in a somewhat less pretentious but not less useful work by the same writer and publishers, *Oil Colours and Printing Inks.*

Ink and colour mixing.—It is by no means unreasonable to suggest that the printing ink maker should have an intimate knowledge of ink and colour mixing. Such a knowledge would enable him to so manipulate the various pigments that the best possible results might be obtained with them on the printing machines, and by a skilful mixing of the inks at his disposal produce any shade or tone of colour required. To succeed in this phase of his work the printing ink maker must have a fair knowledge of the conditions under which the pigments are likely to be used, and, as far as possible, anticipate some of the emergencies of the printer's work. Then again, in some printing establishments, where a considerable amount of repeat work is handled, the printer may need to standardise his colours as far as possible, and to requisition a regular supply of inks of some particular hue or shade, at the same time indicating the approximate conditions under which they will be worked, and maybe stipulating also that the inks must be ready for the printing machines without further preparation. The printing ink manufacturer must therefore have an intimate knowledge of "Ink and Colour Mixing". The chapter bearing this title has been carefully compiled, chiefly from the practical printer's point of view. In fact it is a printer's chapter pure and simple, but arranged for the benefit of the printing ink maker. As far as it is possible to do so, within the limits of a single chapter, a full range of possibilities and probabilities is discussed, and the normal requirements of lithographic and letterpress printers clearly described.

In the various chapters of this work the chief endeavour will be to discuss the manufacture of printing inks in a work-a-day fashion, giving, wherever possible, cause and effect as experienced by the printer. This may perhaps be regarded as a somewhat unorthodox procedure. Yet, after all, the printer's experiences and the printer's needs must be accepted by the printing ink maker as matters for fullest consideration. Occasionally the text of this volume leaves the beaten track somewhat, so that the work may be sufficiently comprehensive to give it a distinct practical value. It may not always suffice to point out an error and indicate a remedy. Some degree of intelligent application must be inspired, and any reasonable digression will be justified if a clearer knowledge is conveyed thereby, and a skilful and accurate application of it guaranteed. Knowledge and accurate application are inflexibly interdependent, and it is almost impossible to overestimate the importance of their relationship. The story is related of an Irishman who was told to smoke some glass if he wanted to see the eclipse of the sun. Pat was keenly disappointed with the result, and said to a passing friend that either the man who told him to smoke the glass was fooling him, or he had got the wrong sort of glass, for, he declared, with another vicious draw at his old pipe, "I can't even get it to light". There is a vast amount of truth suggested by this tale, for it is quite possible to rely too much upon apparatus and what may be described as technical knowledge. Tools, however ingenious, and knowledge, however complete, will ever be dependent upon a right application and skilful handling.

CHAPTER II.

LINSEED OIL.

Extraction of the Oil—Clarification—Mechanical Purification—Adulteration—Boiled Oil—Preparation of Boiled Oil—An Alternative Process.

LINSEED oil is obtained from the seeds of the flax plant *Linum usitatissimum.* This plant is extensively cultivated in various parts of the world, and especially in Asia. The oil is extracted from the seeds in two ways, *viz.*, by mechanical pressure or by a treatment with suitable volatile solvents. For extraction by pressure the seed is cleaned and ground to a meal, then heated either by injected steam or in a steam-jacketed receptacle. The meal is immediately filled into shallow canvas bags and placed in powerful hydraulic presses, the pressure of which forces out the oil, and at the same time expresses a foreign matter known as "foots". The "foots" are separated from the oil either by filtration or by settling in storage tanks. In the other method of extraction referred to, the crushed linseed, together with the volatile solvents, is placed in air-tight iron cylinders. Of the many suitable solvents bisulphide of carbon, canadol, petroleum ether and benzole are the most useful, but the first-mentioned solvent is most commonly employed. The chief advantage of this method of extraction is an increase in the yield of oil, sometimes as much as a 5 per cent. increase over the hot-pressure process. In many instances the oil cakes, formed in the oil presses of the first-mentioned process, are finally treated with the solvents so as to completely dissolve out any oil which may remain. Cold-pressed linseed oil and the oil obtained by means of solvents are usually pale in colour, while the hot-pressed oil is much darker.

Linseed oil which is to be used for varnish-making should be sweet and free from any tendency towards rancidity. It should be filtered and clarified as soon as possible, so as to free it from such foreign matter as may have been introduced during its expression. The presence of this foreign matter, which is usually of a gummy or mucous character, will frequently produce a rancidity which depreciates the value of the oil for varnish-making. Linseed oil has more power of absorbing oxygen than any other drying oil, but fermentation or rancidity appreciably reduces this power, and thus impairs its usefulness and value for varnish and printing ink making. Several methods have from time to time been adopted for the clarification of linseed oil. Probably the simplest of these methods is to heat the oil very slowly to about 100° Centigrade, and keep it at that heat for one hour. Allow the oil to cool undisturbed and afterwards transfer to a storage tank so that it may deposit its impurities. Sometimes calcined magnesia, or carbonate of magnesia is added to the linseed oil before heating. This particular method of clarification or refining is technically known as "mechanical purification," when the comparatively heavy powders, already referred to, gradually settle to the bottom of the tank and in doing so carry with them any particles of foreign matter which may be held in suspense by the oil under treatment. There are, as already pointed out, several other refining processes, all more or less useful no doubt. The point of importance, however, is this—that linseed oil, which is intended for varnish-making, should be very carefully purified. Clarified or refined linseed oil will improve by keeping. It becomes paler and more transparent as it matures.

Adulteration.—Linseed oil is frequently and often very cleverly adulterated. Some of the best-known adulterants are benzine, fish oil, cotton-seed oil, rosin oil and turpentine. Simple tests will usually detect any of these. It has already been pointed out that linseed oil possesses the power of absorbing oxygen from the air in a much greater measure than any other oil. This, being a distinctive characteristic, indicates a fairly reliable and simple test for purity. Adulteration, with any other oil, appreciably reduces this oxidising tendency, and consequently affects its drying qualities. This is a point of vital importance, for it concerns the practical value of linseed oil, for whatever purpose it may be intended. A "rough and ready" method of testing for adulteration with benzine, fish oil, rosin oil or turpentine, is to take a few drops of the suspected oil between the fingers or the palms of the hands. After rubbing them together for a few moments the distinctive odour of any adulterant may be readily recognised. More elaborate and very much more satisfactory tests can of course be applied, but a detailed description of them would be somewhat outside the scope of this work.

Boiled linseed oil has no direct application to the manufacture of printing inks, but it is sometimes employed by the letterpress printer, and occasionally also by the lithographic printer, as a reducing medium for their printing inks. For this purpose very little boiled oil is used at any time, because it oxidises rapidly and has a tendency to make the pigments gummy. However, it will be useful to know its composition and properties, and these will be described in the briefest possible manner. The theory of boiled linseed oil is exceedingly simple. According to a recent authority 80 per cent. of raw linseed oil consists of linoleic acid which, upon exposure to the air changes to linoxic acid. This change is due to the absorption of oxygen by the oil. Of course, boiling, together with the addition of some suitable drier, accelerates oxidation, or, according to the authority already quoted, hastens the change of linoleic acid to linoxic acid, and it is the linoxic acid which is chiefly responsible for the excellent drying qualities of boiled oil.

In the preparation of boiled oil by the old method only the surface of the oil was exposed to the air, an occasional stirring and the ebullition of the boiling liquid producing a sufficiently effective circulation. In the modern methods of oil boiling, circulation is kept up by a revolving stirrer or some equally effective appliance. A constant stream of air is also forced up from the bottom of the boiler and thus intimately

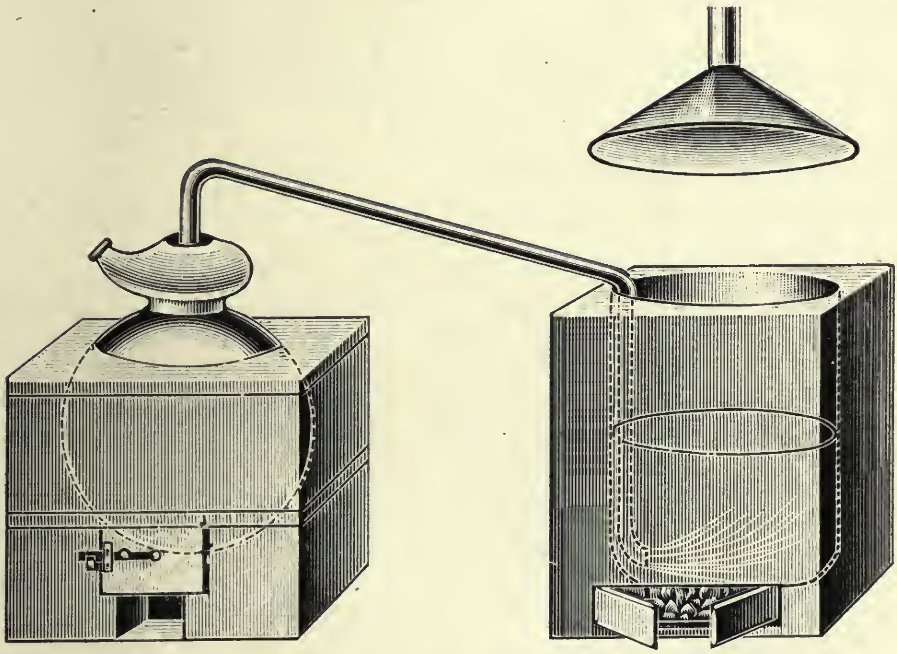

FIG. 1.—American Plan for Boiling Linseed Oil.

mixed with the boiling oil. When linseed oil is heated to a temperature of 300° F., and either oxide of lead or oxide of manganese is incorporated with it, its drying properties are very considerably increased, and it becomes the boiled linseed oil of commerce.

Heating linseed oil to such a high temperature as that indicated—*viz.*, 300° F.—darkens it somewhat, and very often a light coloured oil is preferred. This preference suggested a process in which the metallic oxide is dissolved in a small portion of hot raw linseed oil and then added to the bulk, which has in the meantime been heated to about 100° F. This method is of American origin, but it has since found much favour with users generally. The following extract from an American authority is both suggestive and interesting in this connection:—

"The character of boiled linseed oil, as it is described even in the latest books, does not agree with much of the oil now made in this country. It is described in the literature as being made at a high temperature in the old-fashioned way, whereas, little, if any oil is now made in that way. There is a strong prejudice in the minds of most of the users of boiled oil in favour of the old-fashioned "kettle-boiled" oil. Consequently the manufacturers are somewhat averse to admitting that their oils are made after the modern fashion, although no advantage can be claimed for the old way. This predilection in favour of strongly heated oil is so strong that the dark colour of the old oil is imitated by the use of dark coloured driers, although it is perfectly evident that for use with all light coloured pigments, the lighter an oil is in colour, other things being equal, the more desirable an oil is."

CHAPTER III.

VARNISH.

A Vehicle and Essential Component—A Reference to Lithography—Baltic Oil—Preparation of Varnish—The Modern Method—An Old Argument—Letterpress Varnish—A Cheaper Medium—A Suggestive Recipe—Fire Risks—Gradations of Varnish.

Varnish, in its association with printing inks, is usually and correctly described as a vehicle. Yet it is something more than that. It is, apart from the actual colourant and base, the one essential component without which colour pigments would be all but valueless as printing inks. In printing inks the varnish not only carries the colouring materials and binds together the base, but it gives luminosity to the pigments, and generally imparts to the colours an added richness and intensity. It also renders possible their mechanical manipulation in the printing machine. The usefulness of this varnish to the printer rests mainly on the fact that when it is fully matured it possesses a good, full body, together with fair drying properties, and, what is of primary importance, freedom from excess of greasy matter. It is in fact the medium which holds together the various colours so as to produce pigments of a suitable working consistency. The varnish therefore plays an important part in the preparation of printing inks. In letterpress printing that part is largely mechanical, when the varnish saturates and binds together the loose particles of dry colour into some measure of cohesion, yet in such a manner as not to interfere with free distribution through the rollers to the printing forme and the subsequent transference to paper as an impression.

In lithographic printing this varnish, when properly prepared, fulfils the many exacting requirements of that phase of chemical affinity upon which lithography is based. For a clearer understanding of this characteristic a brief reference to the chemical theory of lithography is advisable. Such a reference will make this, and probably other statements which are included in the text, more definite and considerably more practical in their application. Here, then, are the simple elements of lithography. (1) A porous limestone of a suitable homogeneity of texture, and with a natural affinity for both grease and water. (2) The mutual repulsion of grease and water. The primary object of the lithographic printer is to maintain a perfect balance of these two attributes. Excess of water will impair the greasy affinities, while, on the other hand, any excess of grease will get beyond the control of the water. The reasonable assumption, then, is this, that lithographic printing inks should contain just sufficient grease to maintain the balance already referred to, and this control is largely influenced by the varnish in the pigments. Moreover, this varnish, as in letterpress printing inks, gives a body and cohesion to the pigments, a sufficient viscidity without harshness or undue tenacity which is even more desirable for lithographic printing.

The best varnish for printing inks is made from *Baltic linseed oil.* For lithographic varnish especially, no other quality of oil should be used. Baltic oil is peculiarly free from fatty matter, a feature which is sometimes attributed to the climatic conditions under which the flax plants are reared, but more probably due to the character of certain foreign seeds which are unavoidably harvested with the linseed, and cannot always be completely separated therefrom. Be that as it may, the point of interest to the printing ink maker is not the cause so much as the effect, and it has been conclusively proved that varnish prepared from Baltic linseed oil is comparatively free from scum and excess of grease. A thoughtful perusal of the preceding paragraph, referring two valuable characteristics to the elements of lithography, will at once demonstrate the importance of this characteristic. For letterpress printing inks these features may not be quite so influential, since the operations are mechanical only. In this connection, if desired, the Asiatic or the South American linseed oils might be used. Yet it is scarcely worth while to make the difference. The Baltic oil undoubtedly produces a superior varnish for all printing purposes, and even for letterpress printing inks an appreciable improvement will be effected by its employment. A low grade varnish will not possess that peculiar quality which imparts to printing inks a full body without excessive viscidity. Then again, the employment of unsuitable materials in varnish-making may possibly produce an article which will develop a grease stain on the paper during or after printing, and thereby surround the impression with an unsightly halo. From the foregoing arguments it will be clearly understood that the essential properties of printing inks are chiefly dependent upon the nature of the varnish used in their preparation, and a full appreciation of this point is of primary importance to the printing ink manufacturer.

An experienced practical worker once remarked that the successful preparation of varnish required the greatest knowledge, experience and care, together with a skill which could not be taught by precept, but only acquired by long practice and observation. Which means, of course, that text-books, however complete they may be, can supply the materials only. Successful production can only be guaranteed by practical experience. The process of varnish-making will first of all be briefly outlined, and the details filled in as the descriptions develop.

"Raw linseed oil is matured and oxidised until its consistency is considerably changed. It is further reduced in bulk by being boiled at a high temperature. As this boiling continues the fumes, which quickly arise, will ignite, and the liquid soon assumes a syrupy or stringy character. By extending or discontinuing the burning, the varnish may be produced in a variety of grades." This refers to the older method of varnish-making. The modern process entirely dispenses with the burning, when a much lighter coloured varnish is the result, but the operation is very much slower than the old-fashioned way already described.

The following is a description of the modern method of varnish-making, *i.e.*, without burning. The iron boiling-pot must hold about three times the quantity of oil it is intended to boil, and should have a close-fitting lid with a long handle attached thereto. This apparatus should be arranged so that the fire can at any time be *immediately* drawn from under the vessel, or as an alternative, so that the vessel, *i.e.*, the boiling-pot, can be conveniently removed from the fire. The control of the fire as suggested is probably the better arrangement, for then the temperature of the oil can be regulated at will. The oil should be heated to 550° F. and kept at that temperature for about six hours. It is for this that the heating arrangement, as referred to in the preceding paragraph, should be under perfect control. At a temperature of 550° to 600° F. the fumes rising from the boiling oil are dangerously near the ignition-point, and if, by any chance, they should ignite, the fire must be immediately withdrawn, or the vessel removed, as the case may be, and the cover firmly closed. It should not be a very difficult matter to arrange a sliding fire-grate underneath the varnish-pot, and this would give a convenient, simple and effective control of temperature. The boiling oil will gradually thicken, and should from time to time be tested for the different gradations of varnish. A little of the liquid, withdrawn from the pot and cooled, will at once indicate the stage of viscidity which the varnish has reached, when, of course, the boiling can be continued or stopped as desired. The old argument that linseed oil must be both boiled and burned before it can be brought into a proper state for the preparation of printing inks, has been to some extent disproved in modern practice, yet for some purposes—notably gold-leaf work—a burnt oil varnish is preferable. For the preparation of such a varnish linseed oil is boiled in the manner already described and the vapours ignited as soon as they will burn. The pot is removed from the fire but the burning is allowed to continue until a sample of the varnish, when cooled, indicates the right consistency. The following detailed description of the manufacture of letterpress printing varnish by the burning process will be interesting and useful: "Place one and a half gallons of linseed oil in an iron pot and make a fire under it. After a time the oil simmers and bubbles up, but as the temperature increases the surface resumes placidity; next it commences to smoke, and then to boil, emitting a very strong odour. As the boiling continues a scum arises. At this stage repeated tests should be made to see if the vapours will ignite. When they will do so, the pot is removed from the fire and placed on the ground. In the meantime the contents are very frequently stirred and kept burning. Samples are occasionally withdrawn to test the consistency of the varnish, for which purpose the flames must be extinguished by covering the pot. When drops of the varnish, after cooling, will draw out into strings about half an inch long it is suitable for an average letterpress printing ink, and the flames are finally extinguished. This completes the varnish, but it is customary to add other ingredients, which may or may not enhance its value for printing purposes. On removing the lid of the pot there is much frothing and a great escape of pungent smoke. The froth will subside after a thorough stirring, upon which six pounds of rosin are gradually introduced and stirred in. When the rosin is dissolved, one and a half pounds of brown soap is cut into slices and stirred in piece by piece. When all the soap is in and the frothing once more ceases the pot is returned to the fire until its contents begin to boil, constant stirring being maintained. This completes the operation."

It is quite sixty years since it was first suggested to use a cheaper medium than varnish prepared from linseed oil for letterpress printing inks. Resin oil, resin and soap were intimately mixed together and afterwards ground with the lampblack for newspaper inks. Nor is it by any means an uncommon practice to-day to prepare similar printing inks with resin oil mediums. A considerable amount of latitude is permissible in the manufacture of such inks, and the materials may be proportioned to meet such conditions as price, climate, or other exigencies of the work may dictate. It is advisable, however, to retain as much of the true linseed oil varnish as the conditions referred to will permit.

L. E. Andés, in his work on *Printer's Inks*, etc., recommends the following method of preparing a cheap vehicle for the manufacture of common letterpress printing inks: The varnish, already described, is only boiled sufficiently to destroy the excess of grease in it, and "the thickness then wanting is given by the addition of resin. When the oil has been boiled it is left to clear for a short time, and then re-heated to receive the resin, which must be as dry as possible and broken into small pieces. These pieces are fused over a gentle fire and then mixed, first with some resin soap which has been cut up, and when that has dissolved with the hot oil. The mass is constantly stirred, left on the fire till it is very thin, and then filtered through a linen cloth to remove all the impurities of the resin. The finished vehicle is allowed to deposit all particles too fine to be stopped by the cloth, and after a few days is drawn off from the sediment." In this connection the same writer gives a series of suggestive recipes, one of which is quoted below.

	Thin Vehicle.	Medium Vehicle.	Thick Vehicle.
Resin	25 Parts.	25 Parts.	25 Parts.
Boiled linseed oil . .	100 ,,	100 ,,	100 ,,
Resin soap	3 ,,	3 ,,	3 ,,
Partly boiled linseed oil .	7 ,,	4 ,,	—

Very considerable fire risks are involved in the manufacture of printing varnishes. Constant care and watchfulness is required at every stage of the operation. It has been pointed out that the boiling oil should be maintained at a temperature which is just approaching the ignition-point, and herein lies the danger, for even the slightest increase of heat may fire the liquid. A prompt closing of the boiler lid will at once extinguish the flames, should they arise. It is important therefore that the lid should be close fitting, and have a long handle extending well beyond the reach of possible flames. Another excellent extinguisher is a strong metal grid or net. The advantage of this over the ordinary lid is that it extinguishes the flame quite as effectively, yet allows the fumes to escape. Then there is an ever-present risk of the oil boiling over. To minimise the danger in this respect, the pot or boiler should be fitted with a flange which will completely overlap the fire hole (see diagram). Then if by any mischance excessive ebullition should cause the oil to overflow, this flange will prevent it from reaching the fire. With reference to excessive ebullition of the oil when boiling, old linseed oil is safer to use than new. It does not boil quite so viciously, and therefore produces much less ebullition.

Varnish for printing inks is usually manufactured in four and sometimes in five strengths or grades, *viz.*, Tint, Thin, Medium, Strong and Extra-strong. The two extreme varieties, *i.e.*, tint varnish and extra-strong varnish, are not employed by the printer under normal conditions; while for printing ink making they might never be required at all, unless for the preparation of an exceptionally soft pigment without adding too much to its bulk and thereby reducing both covering and colouring power. The tint varnish would be useful under such conditions. The extra-strong varnish is mixed with inks when extraordinary tenacity is desired—as, for example, the

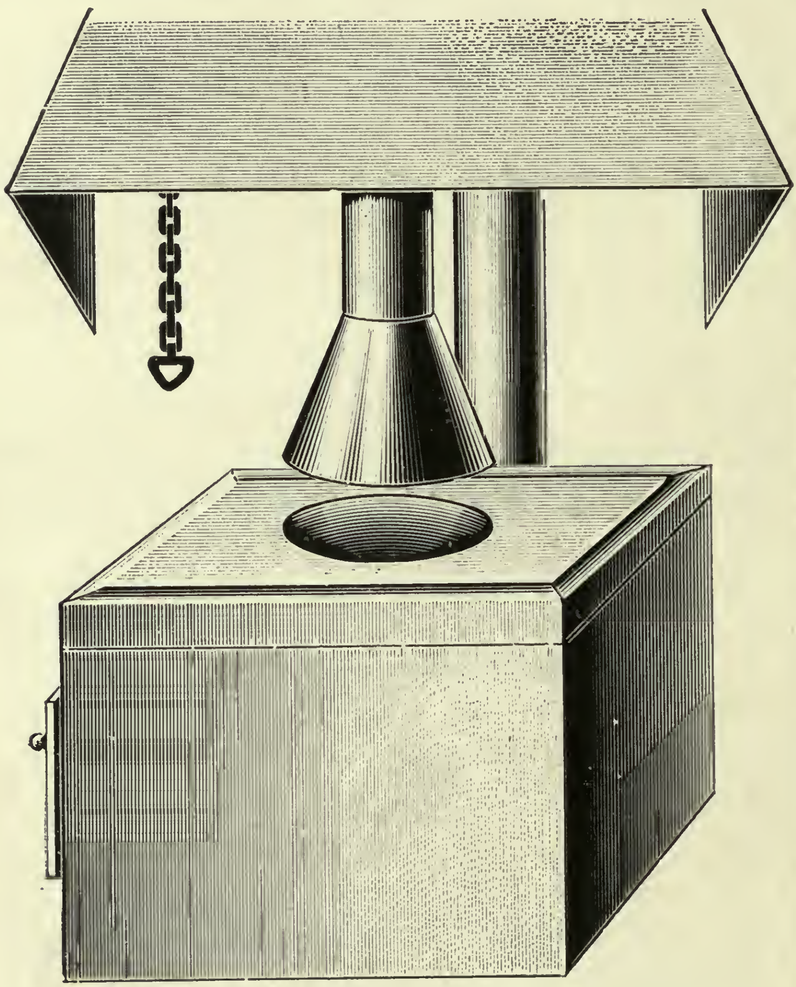

FIG. 2.—French Apparatus for Varnish-making.

pigments used as mediums for gold bronze or metal-leaf work. The three gradations of varnish, thin, medium and strong, may be used separately or together, according to the character of the ink under preparation. If great density is required, then the thinner varnishes may be used, for then it will be possible to work the dry colour into a pigment without an excessive addition to its bulk. This recommendation, however, must be qualified, for there are several exceptions, the most notable of which is vermilion. Several of the chrome yellows and sometimes the whites may also be regarded as exceptions. The "why and wherefore" of this matter will be fully discussed in a later chapter, "Ink and Colour Mixing".

CHAPTER IV.

DRY COLOURS.

A Recommendation—An Endless Variety of Materials—Classification of Colouring Materials—Earth Colours—Mineral Colours—Substrates—Toning Earth Colours—Physical Characteristics—Colouring Power—Brilliance—Purity of Tone—Permanence.

THERE was a time, and that quite recently, when the printing ink manufacturer had no choice but to prepare the dry colours which enter into the composition of printing inks, and it is frequently recommended that he should do so even now—especially as regards black. It is, however, vastly more economical and satisfactory to obtain the dry colours from manufacturers who specialise in their preparation, for their variety is almost bewildering and the manner of their production ever changing and improving. A thoughtful perusal of the introductory chapter will surely convince the reader that the printing ink maker's responsibilities are already sufficiently numerous and exacting without adding to their number. It would be better for him to devote his skill to the fulfilment of these responsibilities and in this way satisfy the demands of his clients. Such a limitation of his work does not necessarily involve a limitation of knowledge thereof. It is very important indeed that the printing ink maker should be in possession of complete and reliable information concerning the composition and characteristics of all bases and colours, whether they are prepared by him or for him. He should also be well acquainted with their chemical principles and attributes, so that he may be able to utilise their peculiar qualities to the best possible advantage.

As already pointed out, materials for the manufacture of printing inks are now produced in almost endless variety, so that it is possible to secure an extensive range of colour combinations and effects, and at the same time satisfy the very many requirements of different phases of reproductive art. It has been suggestively remarked that "a few years ago the colour maker was limited in his choice to a comparatively small number of raw materials, mostly inorganic in their origin, and whose chemical and physical properties were fairly well understood". At the present time, however, he is confronted with a host of new colorants, whose value can only be ascertained by a lengthy series of experiments. The brief descriptions of productive methods with reference to dry colours, colorants, etc., which are included in this work are primarily intended to emphasise important characteristics of the materials and thereby to assure their successful manipulation. They are not offered as complete instructions for manufacturing purposes. The actual preparation of dry colours and other materials, although of course very closely associated with the manufacture of printing inks, is now quite a separate industry, or rather a series of industries, for several manufacturers have very wisely specialised the production of certain materials, and in this way identified them as independent concerns. This is notably so with the manufacture of blacks, and it offers ample scope for progressive thought and work.

The colouring materials from which printing inks are manufactured are either natural products, as, for example, the numerous earth colours, or artificial preparations, such as the precipitated dyestuffs. The former, *i.e.*, the natural earth colours, usually require but little preparation, perhaps only a certain amount of refining, to render them useful for the manufacture of printing inks. The preparation of the artificial products referred to is almost exclusively controlled by chemical principles, and may be either a metallic precipitation or simply the separation of some vegetable dyestuff.

Accepting the term in its broadest application, the range of earth colours is somewhat extensive, since it can claim to include most, if not all, the inert bases used as substrates for printing pigments. Carbonate and sulphate of lime, heavy spar and magnesia are the best known of these bases, but as independent pigments they are almost valueless. Of the actual earth colours, however, the most important are yellow ochre, cinnabar (ferric oxide), green earth, sienna, umber, and manganese brown. Graphite is sometimes included in this category, but its composition places it quite outside the interest of the printing ink maker. According to a reliable authority "the earth colours are the decomposite products of minerals, especially the earth colours containing ferric oxide, and according to a more or less advanced decomposition these transformation products exhibit different qualities and degrees of purity". The natural earth colours should not be confused with the mineral colours, which are of a somewhat different character, and include lead white, zinc white, chrome and Naples yellow, cobalt and Prussian blues and some of the greens. Cinnabar is sometimes classified as a mineral colour, but this difference of opinion will not materially affect the present discussion.

The two most prominent methods employed in the preparation of dry colours are the simple *dyeing* of suitable bases technically known as substrates, and the *precipitation* of some dyestuff upon a substrate. In either method the results are the same, the substrate becoming permanently coloured by the dyestuff in whatever form or manner it may be applied. Heavy spar, kaolin (china clay), baryta, hydrate of alumina, and magnesia are well-known substrates. They possess the peculiar quality of absorbing basic dyestuffs and rendering them to some extent insoluble. In this respect heavy spar may be regarded as a typical substrate. It is practically an inert substance and usually insoluble in alkalies and acids, hence its suitability as a printing ink base. Its employment in this respect is perfectly legitimate and often unavoidable, and the same claim may be justified on behalf of the other substrates. When, however, they are employed to add bulk and weight to printing inks so as to cheapen their manufacture, they must be considered as adulterants, for they are inert materials, with very little covering power in proportion to their bulk. It is chiefly on account of such substrates or bases in printing inks that it is difficult to indicate a standard for adulteration.

There is yet one other process of colour manufacture which is occasionally employed. A coloured substrate is dyed with a brighter tone of the same colour. In this way the sombre tones of some of the earth colours may be strengthened and brightened. When, for example, such a substrate is intensified by one or other of the brilliant coal-tar colours, its colouring power and general effectiveness will be considerably enhanced. Up to a certain point this device is excellent for the production of bright, strong colours, but the toning element frequently lacks permanence, and then the manufactured pigment, though cheap, is eventually disappointing.

The physical characteristics of precipitated colours are especially important to the ink maker, because they almost invariably communicate their texture to the pigments with which they are associated. These characteristics may be divided into two classes—Amorphous and Crystalline. Amorphous substances are comparatively smooth in texture and capable of almost complete saturation by varnish or any similar vehicle, while Crystalline substances are much less finely divided, and therefore not so smooth in texture. Consequently they have not the same density or covering power. As a rule, chemically prepared colour pigments, and particularly such as are produced by precipitation, are richer and more brilliant in tone than the natural earth colours, but do not always possess the same covering power or reach the same standard of permanency.

Apart from the purely commercial aspect of colours, *i.e.*, price and convenient supply, the chief points for consideration should be (1) Colouring power; (2) Brilliance; (3) Purity of Tone; (4) Permanence.

Colouring power or colour value indicates the actual colour strength of the materials and not their density only. Density does not necessarily depend upon strength of colour, and is more expressively described as covering power. Tests for colour value can only be made by comparison either with other colours or with some recognised standard. The following ingenious test for comparative intensity of colour was suggested by a well-known writer: Equal quantities of each colour to be tested are placed in test tubes and diluted, in any convenient manner, until they all show the same depth or intensity. The volume of each solution will be a fairly accurate indication of colour strength. If the volume of one is greater than that of another, then its colour strength is less in proportion to that difference in volume. "The value of a colour," according to a recent authority, "depends entirely upon its power, *i.e.*, how much of the actual colorant it contains."

Brilliance chiefly concerns the brightness and general effectiveness of a colour, and is frequently closely allied to purity of tone. It must be remembered as a qualifying feature that many of the most fugitive colours are the most brilliant and, for a time, the most effective. A brief reference to the brilliance of a certain class of colours is contained in an earlier paragraph of this chapter.

Purity of tone is one of the most important attributes of a colour. It may be tested by the spectrum, but for ordinary commercial purposes the test is usually a comparative one, based upon a known standard or decided by the purpose for which the particular colour may be required. For example, a blue required for mixing with yellow to produce a bright green would not, for that purpose, be considered as pure in tone if it inclined towards the purple or violet hue. In like manner the argument may be extended to other colours. It may sometimes be difficult to ascertain the exact tone of the more intense colours, especially when they are made up as pigments. A simple plan is to reduce the colour strength by the addition of white, when the increase of luminosity will at once reveal the slightest inclination of tone.

Permanence refers chiefly to the effects which atmospheric changes or exposure to light may produce in colours. Some time ago an observant experimentalist pointed out that colours are almost as much affected by atmospheric conditions as by the well-known action of light, and that colours prepared on a lead base, or containing lead in any form whatever, are perceptibly altered by the sulphurous coal gases with which the atmosphere of large towns is frequently overcharged. Some of the chrome yellows, being chromates of lead, have a tendency to blacken in impure air. Ammonia fumes have also a bad effect upon many of the colours used in the preparation of pigments. Ammonia is an exceedingly powerful alkali, and its fumes are freely generated by stable and other refuse of a similar character. Many colours, and particularly several of the lakes, are extremely fugitive when exposed to bright sunlight, and even under the action of light generally. This characteristic is so pronounced in some colours that they can only be satisfactorily employed for printing which will afterwards be more or less excluded from light, as, for example, book illustrations, etc. The commercial value of permanence in printing inks is recognised even outside the printing trade. Its recognition, therefore, by the printing ink maker, is imperative.

CHAPTER V.

DRY COLOURS—BLACKS, WHITES, YELLOWS.

Lampblack — Process of Manufacture — Calcination — Carbon Black — Acetylene Black—A Simple Test—Lead and Zinc Whites—White Earth Colours—Yellows—Yellow Ochres—Mineral Yellows.

THE following description of the various dry colours will indicate their usefulness to the printing ink maker. Not very many years ago a text-book stated that printer's ink consisted of vehicle and lampblack, which statement was quite true perhaps at that time, or nearly so. However, the point I wish to emphasise is this, that black printing ink is the pigment most extensively used by the printers, hence its claim to first consideration. There are several varieties of dry blacks which may be used by the printing ink maker, but of these the most useful is "lampblack". Lampblack is frequently regarded as a commercial term of somewhat elastic application, yet the true material has definite characteristics which cannot easily be counterfeited. "Lampblack is understood to be the soot resulting from partial combustion of any substance containing carbon, be it oil, resinous substance or natural gas." Another authority describes lampblack as "a nearly pure form of amorphous carbon, obtained by the imperfect combustion of oil and resin".

The manufacture of lampblack is not by any means an inflexible process. It varies considerably, but chiefly in the selection of materials employed and the manner in which the results are collected. The selection of material is usually influenced by the question of convenient supply, and their preparation by individual ingenuity and resource. The variety of raw materials is extensive. Fish oils, tar oils and vegetable oils are all alike suitable, since they are rich in carbon and burn freely. The standard of suitability laid down by an experienced German worker is simple yet suggestive, and is indicated by "the difference between the amounts of oxygen which the various materials require for complete combustion, *i.e.*, for burning with a luminous and non-smoky flame. The more oxygen an oil needs to burn smokelessly, the better it is for the lampblack making, and it is easier, by restricting the air supply, to make them burn smoothly". The apparatus for consumption must be adapted to the material employed, but the principle is much the same throughout, *i.e.*, that the apparatus shall consume just sufficient carbon to maintain combustion and thus produce a smoky flame. The arrangements for collecting the lampblack produced by this flame may consist of a simple chamber or series of chambers through which the smoke is conducted, and this phase of the work, as already pointed out, is entirely controlled by individual ingenuity and resource. One notably novel arrangement of this kind consists of a water-cooled cylinder, revolving slowly over a row of oil lamps. Brushes adjusted to this cylinder remove the carbon produced by the smoky lamps and throw it into a convenient receptacle.

The lampblack is subsequently purified by calcination. The carbon produced by burning oil, etc., contains impurities—substances which are the products of dry distillation, and impart to the lampblack an undesirable brown hue. These impurities are removed by calcination, when the material is heated in what are practically air-tight boxes. A red heat kept up for at least thirty minutes will drive off the volatile substances, and, if successfully applied, will impart to the carbon a full black tone, and an extremely soft and flaky texture. For a lampblack of exceptionally fine texture and depth of colour, calcination is repeated three or four times. The purification of lampblack and the complete elimination of grease from it partly destroys its colour strength, but this may be restored by the addition of carbon (natural gas) black.

Carbon black is glossy in appearance, with a somewhat granular texture, but it is not greasy. It is prepared by burning natural gas, which is conveyed to burners direct from the gas wells. Extraordinary care is exercised in the preparation of carbon black. The pressure of gas and also its temperature must remain uniform throughout the operations, and also the temperature of the collecting plates and rollers. In fact a great deal depends upon this uniformity of temperature which appreciably influences the texture and general physical character of the black produced. In America the supply of natural gas appears to be almost unlimited, but some of the lighter qualities, being deficient in carbon, are scarcely suitable for the manufacture of carbon black. It is estimated that for every pound of carbon black produced about 2,500 feet of gas has to be consumed.

Acetylene black is also an amorphous carbon black of peculiarly fine texture. It is dry, light, and of constant composition. The colour of acetylene black is full, rich, and having a blue tone. Owing to its amorphous character, the covering power of acetylene black is very satisfactory. The process of manufacture is the subject of several patents, all of which are based upon the decomposition of acetylene by the aid of electricity.

A simple, yet practical, test of comparative colour values of the various blacks is to mix a small portion of each material under examination with 80 to 100 times its weight of dry white. Prepare each mixture as a pigment, with oil, varnish or water, when their comparative colouring or staining powers can be ascertained by spreading a little of each thinly and evenly on a piece of glass. This test does not, of course, decide the suitability or otherwise of the blacks for printing purposes. Such a test can only be applied under actual working conditions.

White does not play a very important part in the manufacture of printing inks, excepting of course in the pigments prepared for tin-plate decoration. In small quantities, however, white is very useful in colour printing, but is seldom used alone. In this connection the chief point for consideration is the probable chemical action of the white upon the colours with which it will be mixed. White lead possesses unrivalled covering power and produces a pigment of dazzling whiteness. It will, however, change colour when mixed with colours containing free sulphur. Ultramarine has frequently an excess of free sulphur in its composition, and if mixed with white lead the result will be a curious grey tint and not a brilliant light blue, as might be expected. White lead is basic lead carbonate. The Dutch process of manufacture exposes the metallic lead to vinegar vapours—carbonic acid and oxygen. The first result is a basic lead acetate and finally white lead. This process produces a white lead of excellent quality. The methods employed date back to the beginning of the seventeenth century, and although improvements have been effected in some minor details the main principles have remained unchanged. The German chamber process, the French precipitation process and the later electrolytic process of manufacture are each capable of producing a commercially satisfactory white lead, but the peculiarly dense product of the Dutch method generally gives the best results. Zinc white is much more satisfactory for the manufacture of printing inks. It may be a little less luminous in its effects, and it certainly does not possess the covering power of white lead, but it retains its original whiteness under normal conditions, and when mixed with sulphurous colours. Zinc white is zinc oxide prepared either from the metallic zinc or from the zinc ores direct. White earth colours sometimes occur in nature, and although they are in some respects useful to the printing ink maker, they cannot be used for the actual preparation of pigments. The most interesting of the white earth colours are heavy spar, barium carbonate, magnesium carbonate and gypsum. These may be used for mixing purposes and as brightening agents. They are almost if not entirely neutral in their action and can therefore be compounded with the most delicate tints without appreciably affecting their purity and brilliance.

The yellow colours form an important series for the consideration of the printing ink maker. They are produced under a bewildering number of commercial names each possessing some peculiar characteristics which recommend or condemn it. The yellow ochres (earth colours) are useful products. Their colouring principle is ferric hydrate and sometimes ferric oxide. These natural earth colours are usually the result of rock disintegration, and vary slightly in colour according to their composition. The usefulness of the yellow ochres for the manufacture of colour pigments is largely due to their permanent character and their cheapness. They are also bright and effective in their colour shades. There is an extensive range of mineral yellows, including the chrome yellows, cadmium yellow and Naples yellow as the most important. Genuine chrome yellow is a lead chromate, and as such has a tendency to blacken in impure air. It is a beautiful colour and of great tinting power, but, as already observed, sensitive and liable to change after a short exposure. Cadmium yellow is a cadmium sulphide and in many respects a desirable colour. It is strong, bright and fairly permanent. It is prepared in a variety of shades but is generally offered as a rich orange yellow. Cadmium sulphide resists weak alkalies and acids. It is in fact an excellent colour for the printer but expensive. What is generally known as Naples yellow is a lead colour which is fairly permanent as regards exposure to light, but liable to chemical changes owing to its composition. Naples yellow is an antimony yellow—lead antimoniate—and fairly permanent unless mixed with some of the other ferriferous colours, such as sienna and Prussian blue, when it changes colour. It does not mix well with vermilion. Raw sienna is sometimes classified as a yellow, but owing to its broken tone of colour can scarcely be regarded as such. It is transparent and permanent. There are numerous other yellows of more or less importance, *viz.*, Mars yellow, zinc yellow (zinc chromate), imitation Naples yellow, baryta yellow (barium chromate), Indian yellow, etc., etc.

CHAPTER VI.

DRY COLOURS—REDS, BROWNS.

Classification of Reds—Genuine Vermilions—Preparation—Imitation Vermilions—Umber, Raw and Burnt—Sienna, Raw and Burnt.

Of the many pigments used by the printer red is one of the most important. Though not nearly so extensively used as black, red enters largely into the composition of almost every form of effective colour design, and is extensively employed by both letterpress and lithographic printers. The reds may be divided into quite a number of varieties, each of which will show distinctive characteristics. There are few, however, which have a real interest for the printing ink maker. Genuine vermilion ranks first, and in all its peculiar features is unrivalled for printing purposes. Imitation vermilion is very useful as a cheaper product where commercial conditions prohibit the use of the genuine article. The natural reds have little or no value for printing ink making. The discussion of them need not be continued beyond this brief classification. The lakes are fully described in a separate chapter.

There are several varieties of quicksilver vermilions; the English, French and Chinese being the most important, but the difference in their manufacture does not materially affect their chemical composition. It does, however, slightly affect their depth of colour, and sometimes also their brilliance. Vermilion is a mercuric sulphide produced by a simple combination of mercury and sulphur, or sometimes prepared from the natural sulphide of mercury cinnabar. One of the simplest methods for making vermilion, by what is known as the wet process, is to heat sulphur and mercury with caustic potash and afterwards wash and thoroughly grind the product. The depth and brightness of the colour is to some extent controlled first by the heating and afterwards by the grinding. In another wet process the same materials are used but their manipulation varied. A cylinder or tube is fitted with a stirring arrangement of the propeller blade type. The sulphur and mercury and a solution of potash are put into this cylinder and stirred constantly and rapidly until the mixture changes first to black mercuric sulphide and eventually to the red sulphide or vermilion, which only requires careful washing, grinding and drying to make it ready for use.

The dry method of making vermilion is generally described as sublimation. The sulphur and mercury are heated together and frequently stirred until they combine to form the black mercuric sulphide. This black sulphide is then re-heated in an earthenware vessel of sufficient size to enable the lower portion of it to be heated while the top part and cover remain comparatively cool. As the black mercuric sulphide becomes sublimed it rises to the top of the vessel, already described, and forms a crust of red sulphide on the cool cover. This, when ground fine, is ready for use. It has already been pointed out that the chemical composition of vermilions is the same, no matter what modifications may be employed in their preparation. A little difference in effect may be produced by the final grinding. A simple, yet practical, test for genuine vermilion is to heat it in a crucible. If the material is pure, only a very little ash will remain after complete sublimation.

The imitation vermilions have been evolved to meet the commercial requirements for cheaper materials. For very many years there has been an increasing demand for strong bright colouring pigments (reds) quite distinct from the vermilions, with their immense covering power and unrivalled opacity, hence the production of imitation vermilions so called. One of the oldest vermilion substitutes is prepared from carbonate of lead and bichromate of potash, but the most satisfactory reds of this class are built up on orange mineral bases toned with eosine or some other coal-tar dyestuff. The cheaper imitation vermilions usually consist of some neutral base such as barytes, dyed with a coal-tar dyestuff, but these pigments are not nearly so useful as the orange mineral bases toned or dyed in the same manner.

Genuine umber is an ochreous earth of olive-brown colour. In the native state the finest qualities are found in Turkey and in Cyprus. The chemical composition of umber is hydrated silicate of ferro-manganese, with sometimes a little alumina. In its raw state umber shows the olive-brown colour already mentioned, but for the manufacture of printing inks raw umber is seldom used. By burning, various shades of colour can be produced, and these are preferred by the printer. The rich brown hue of burnt umber will produce a clear neutral tone of colour which cannot be prepared in any other way. Umber is not only neutral in tone but neutral also in character, inasmuch as it has no effect whatever upon other colours or materials employed by the printer. It is, moreover, an excellent drying pigment and permanent. There are, of course, other brown earth colours which are sometimes toned and supplied as umber, but the genuine article can generally be detected by its greater comparative bulk.

Sienna is another ochreous earth, containing ferric oxide as a colouring principle. It is an exceptionally transparent colour, and when well ground possesses a peculiarly rich undertone. Raw sienna is sometimes classed as a transparent yellow, but it has a distinct broken tone and can only be correctly described as sienna. As a raw colour sienna is only occasionally used by the printer, but as a burnt colour it is well-nigh indispensable. Burnt sienna possesses several of the characteristics of burnt umber. It is a neutral pigment of a clear neutral tone and dries well when used as a printing ink. The best sienna comes from Italy, where it is found in smooth brown masses. In its native state it contains many impurities which are chiefly indicated by variations of colour.

CHAPTER VII.

BLUES, GREENS.

Ultramarine Blue—A Useful Test—Other Similar Blues—Cobalt Blues—Prussian—Chinese and Bronze Blues—A Test for Purity—Greens—Compound Greens—Mineral Greens.

THE blues form a valuable group, or series of groups, of colour pigments for the printer's use. Owing to their extensive variety and peculiar differences they require careful classification, and in some instances detailed consideration. In former times ultramarine blue was regarded as the most celebrated of all pigments, as well it might be, since it was prepared from the rare and costly lapis-lazuli stone. Though now artificially or chemically prepared, ultramarine blue retains many of its excellencies. It is still a permanent colour which is scarcely affected by contact with other pigments or when exposed to impure air, but the modern product will not stand the attrition of many centuries like the colour made by the ancients. It is indeed interesting to note that on some of the ancient Egyptian monuments, where the paintings are supposed to be over 4,000 years old, the ultramarine blue remains with its brilliance unimpaired. Ultramarine blue is prepared from kaolin soda, sulphur and carbon, with sometimes a small quantity of silicic acid. These ingredients are carefully ground and mixed together, after which they are brought to a red heat in fireproof earthenware vessels. This preparation is then slowly roasted at a low temperature while continuously exposed to the air, when the ultramarine blue of commerce is produced. To fit this blue for printing purposes, and particularly for lithographic printing, it must be thoroughly well washed to free it from sulphur, after which it is stirred into water with the addition of 3 per cent. of burned magnesia. A 10 per cent. solution of magnesium chloride is poured into the mixture, and this immediately precipitates the ultramarine, when subsequent filtering and drying render it ready for use. It will not be superfluous to emphasise a point already noted—that ultramarine blue must be free from sulphur to render it fit for the printer's use. A German writer suggested the following simple test in this particular: Mix a very small portion of the ultramarine blue with a little distilled water so as to form a stiff paste. Place this colour on a well-polished copper plate and leave it for twenty or thirty hours. If, on its removal, the plate shows comparatively clean and bright then the colour may be regarded as perfectly safe; but if, on the other hand, the plate is blackened, further washing is desirable. Ultramarine blue is a fine, almost impalpable azure powder, which is impervious to alkalis but readily attacked by acids.

Other blues which are somewhat similar in appearance and effect to ultramarine blue can scarcely be regarded as imitations or even substitutes. Sometimes varieties are arranged for by the addition of kaolin or barytes to the genuine ultramarine blue, when a lighter shade of colour is the result. Blues such as French blue, pure blue, permanent blue, etc., etc., have sometimes brilliance and colouring power but are not nearly so reliable as the colour they frequently presume to replace. Their names rarely indicate either a standard of colour or of excellence. Cobalt blues are usually handsome colours and fairly permanent. They are prepared by precipitation and known sometimes as royal blues, or occasionally by the original name Thenard's blue. The original Thenard's blue is a basic cobalt phosphate prepared by mixing together solutions of cobalt nitrate and alum. A precipitate is then formed by the addition of a soda solution. This precipitate is heated in crucibles, then washed and ground. Later methods have made no appreciable change either in the chemical composition or the character of the materials produced.

Prussian blue, which is also known as Chinese blue and Bronze blue, is one of the most powerful and lustrous colours used by the printer. There is occasionally a little difference in the processes by which these three varieties of blue are prepared, but it is scarcely appreciable, and makes very little if any difference to their commercial value. The premier position is usually claimed for Chinese blue, but the claim cannot always be substantiated. As with many other of the dry colours *quality* can always be regulated by a skilful addition of neutral matter. While discussing this point of quality it will be useful to record a test for purity which was recently suggested by a practical worker: Take a little of the dry colour and rub it out on a piece of white printing paper. If the bronze lustrous effect, peculiar to these blues, is very pronounced, then the colour may be regarded as reasonably pure and suitable for the manufacture of good printing inks. If, on the other hand, the bronze effect is weak, then the colour is suitable only for the lower grades of printing ink, for, in all probability its quality has been lowered by the addition of some foreign material.

Greens are usually compound colours produced by the mixture of blue and yellow in some form or other, but there are several greens, unity colours, which give brilliant and permanent effects and are therefore useful to the printer. Green is a secondary colour, but its importance in many of the colour schemes is considerable. In this particular there is a point well worth noting because it has a peculiar interest for the printing ink maker. Unlike vermilion, ultramarine blue, Prussian blue or any of the well-known yellows, there is not even an approximate standard of colour for green, and the reason for this may be readily appreciated. It has already been pointed out that green is a colour of some importance in many of the colour schemes, but, almost invariably, its hue or shade must be accurately mixed in agreement with the scheme for which it is intended. Consequently the manufactured green has something like a secondary interest for the printer and therefore for the printing ink maker.

A useful range of green colours is prepared by mixing together Paris blue and a chrome yellow with a clean lemon tone. An intimate combination is best obtained by mixing the colours in moist form and afterwards drying and grinding them. Several characteristic greens are produced by a mixture of the aniline colours and a subsequent dyeing of a suitable base. A dark green is manufactured by mixing together a solution of picric acid with a logwood solution, then adding a little soda. Precipitation is effected with plumbic acetate, or for a yellowish green with copper sulphate.

Chrome green is a chromic oxide which may be prepared as a permanent and effective colour. For its preparation potassium bichromate is calcined with sulphur and afterwards treated with a weak solution of sulphuric acid. Washing, drying and grinding conclude the process and produce a green colour which cannot be obtained by any simple mixtures of blue and yellow. Cobalt green is a mixture of cobalt protoxide and zinc oxide. Emerald green is usually a brilliant colour but sometimes far from permanent. It has also been known to penetrate the vehicle or varnish with which it has been ground, and change the colour of other inks over which it may be printed. Emerald green is a chromic hydrate prepared by precipitation when a chromic salt is treated with zinc hydrate. Terre Verte has a silicate and iron base. It is a good colour and makes a satisfactory printing ink. This product, as the name indicates, is an earth colour treated with a solution of hydrochloric acid to carry off the ferric oxide, then washed dried, and finely ground.

CHAPTER VIII.

LAKES.

Characteristics—Lake Derivatives—A Point of Importance—Red Lakes—Madder—Cochineal and Carmine—Brazil Wood—Alizarine, a Coal-tar Derivative—Yellow Lakes—Blue Lakes—Green Lakes.

UNDER this classification printing inks of great brilliance and beauty are produced, but unfortunately they are of varying permanence. The lakes also possess a fineness of texture and strength of colour which, unlike that of many printing inks, is combined with exceptional transparency. In fact, the lakes rank as the brightest and most transparent of the many colour pigments employed by the printer. The term "Lake" is now largely a commercial one, and there is a difference of opinion as to what it actually indicates. A recent authority describes lakes as "the colouring principles of natural substances in combination with organic bases," when the tinctorial qualities of the former, if transferred to suitable bases, are rendered insoluble. Commercially, however, a little elasticity is permissible, and the base of lake colours is frequently a variable quantity. The usefulness of the lake colours for the preparation of printing inks depends to a great extent upon a peculiar characteristic referred to in a preceding paragraph—their insolubility. They are chiefly used for lithographic printing inks, and of course even the slightest inclination towards solubility would render them valueless in this connection. The manufacture of lake colours has undergone many changes during recent years, and natural organic colouring materials have, to some extent, been superseded by coal-tar products and other chemical preparations.

The original lake pigments were prepared with natural colorants, such as cochineal, madder, yellow wood, Brazil wood, etc., but, as already pointed out, the introduction of colours derived from coal-tar changed this phase of their manufacture very considerably. The coal-tar derivatives offered a wider range of colour effects than had hitherto been possible. They also enabled the preparation of lake colours to be carried out with greater facility and at a comparatively low cost. Coal-tar colours are usually more brilliant than what are known as the natural dyes, but very often indeed their permanence is a doubtful quantity, and this point must be carefully and consistently considered by the printing ink maker. Then there is another point of vital importance—the entire success of lake production depends upon the precipitation of the colorant upon a *suitable base, i.e.*, a base which will not depreciate the purity and the brilliance of the colour. Several characteristic precipitants will be briefly indicated in conjunction with the various colouring materials, but it must be distinctly understood that to secure the best results each dyestuff requires its own particular precipitant.

For printing purposes the red lakes are the best known and most useful. These include madder, carmine, crimson and scarlet lakes. The natural colouring materials used for the preparation of these lakes are chiefly madder, cochineal and Brazil wood. The coal-tar dyestuff most commonly used for the red (madder) lakes is alizarine. The madder plant is a native of the south of Europe. Its long root contains a colouring principle known as ruberythrine, and alizarine is produced from this by oxidisation. In combination with certain metallic bases, including iron, tin and aluminium, alizarine forms a series of brilliant dyestuffs which can be employed for the manufacture of what are commercially known as "Madder

Lakes". Hydrate of alumina and phosphate of alumina are suitable substrates for these lakes.

The cochineal form from which carmine, scarlet and other lakes are prepared, contains carmanic acid, which is first produced in the form of a powder. This powder is soluble in water but its full brilliance is best developed in strong alkali solutions. The carminic acid solution thus prepared is of a bright crimson colour and combines readily with soda, alumina, tin and lime bases. Carmine is usually of a bright scarlet colour, but its tone varies considerably. This generally occurs when the lake is prepared from cochineal and alumina, but it will also be useful to remember that the reactions of different metallic salts produce characteristic results. Caustic soda gives a bluish crimson precipitate, stannic chloride a dull purple precipitate, and aluminium sulphate a bright poppy red. Carmine lake is very often adulterated, but falsification of any kind is easily detected, for a strong ammoniacal solution will at once dissolve the genuine colour and precipitate the adulterants as an insoluble residue.

Red lakes prepared from decoctions of Brazil wood are notable chiefly for their permanence. They are also bright and possess considerable colouring power. Aluminium sulphate, in conjunction with the colouring principle of Brazil wood, produces a red precipitate, caustic soda a poppy red and stannic chloride a delicate crimson hue. The colouring principle of Brazil wood, known as "braziline," is soluble in water, and is obtained by a simple digestion of the wood itself, and afterwards precipitated by one or other of the metallic salts already referred to.

Referring once more to alizarine as a colouring principle, it was obviously impossible to continue its preparation solely from the madder plant. Its extensive application to the manufacture of pigment colours demanded a cheaper source of supply or method of production. Chemical research revealed the fact that alizarine was a hydrocarbon of coal-tar, and very soon the natural dye of the madder root was superseded by the vastly cheaper, yet not less effective coal-tar derivatives. Whether obtained from the madder root or from coal-tar, alizarine combines effectively with metallic bases, such as aluminium, tin or lime, and thereby forms a series of precipitants which may be employed in the manufacture of lake pigments of exceptional artistic and commercial excellence. Like several other of the red lakes the alizarine colours vary somewhat in hue, but this variation is entirely under the control of the manufacturer and may occasionally be turned to useful account.

The yellow lakes possess but little commercial value. Though bright and effective in colour they are rarely permanent when exposed to normal daylight, and many of them are decidedly fugitive in colour. The colouring principles of the yellow lakes may be prepared from quercitron bark and what is known commercially as yellow wood. With the yellow lakes, as with the red lakes, distinct changes of colour may be effected by the application of different metallic salts, etc. I have already pointed out that these pigments have but little commercial value to the manufacturer, and the extent of their interest must of necessity be limited.

Blue lakes are sometimes manufactured but very rarely used by the printer. Nor is it easy to appreciate their value. The range of blue pigments is so extensive and so varied in their characteristics that almost every possible requirement in this respect is anticipated. Blue lakes may be prepared from the campeachy wood, when a variation of the metallic salts employed as precipitants will produce the requisite reactions in its colouring principle. Satisfactory blue lakes have been produced by precipitations of alizarine and methylene blues. These colours are fairly permanent and suitable for the manufacture of printing inks, but as already observed the range of blue pigments available covers almost all requirements, and it is not by any means unusual for brilliant lake colours to develop peculiarities, when printing, which somewhat discount their excellencies in other particulars.

The so-called green lakes are usually commercial *manufactures* which perhaps possess many of the characteristics of the true lakes, but very rarely if ever their full rich tone and colouring power. The brilliant aniline dye stuffs made it possible to produce green pigments which are bright and transparent, but they can only be satisfactorily employed to enhance the value of a mixed green, *i.e.*, a green compounded of blue and yellow. Sometimes a solution of methyl green is combined with an extract of the quercitron bark, referred to in a preceding paragraph, and a thick precipitation of emerald green is obtained, and this or some similar method is probably the nearest practical approach to the production of a green lake.

CHAPTER IX.

THE GRINDING OF PRINTING INKS.

Ink-grinding Machinery—Ink-grinding Mill—A Novel Machine—Hand-Grinding—Treatment of Gritty Colours—A Question of Proportion—Approximate Calculation—Soap—Saturation—Friction Heat—Consistent Grinding.

THE grinding of printing inks, which includes a combination of the dry colour with the medium or varnish, calls for the exercise of a considerable amount of judgment and care. The machinery employed for the grinding of printing inks is simple but effective. Three adjustable rollers with convenient scrapers attached, and revolving as shown in Fig. 3, constitute the main

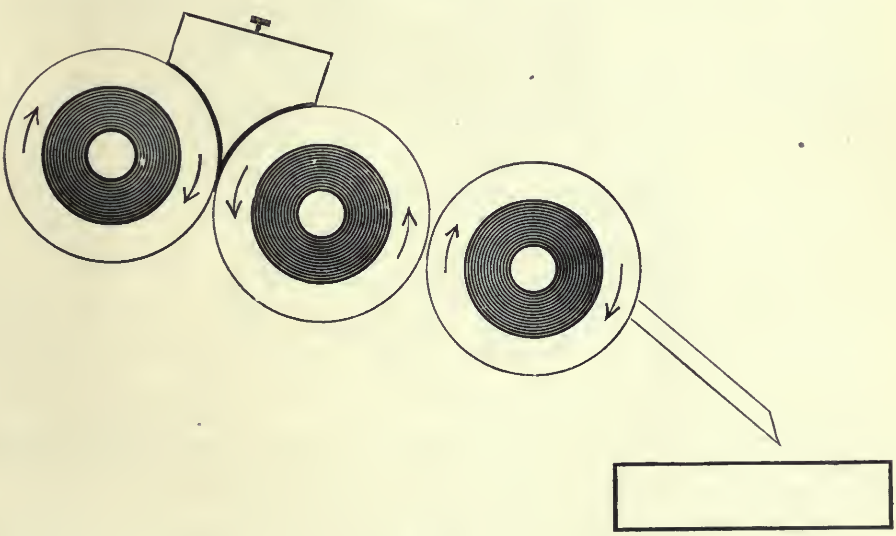

FIG. 3.

principles of mechanical grinding. Complicated disintegrators and mills are not to be recommended. Many printing ink manufacturers have their grinding mills fitted with steel rollers, others prefer rollers made from close grained granite, while a few claim distinct advantages for polished green porphyry rollers. All types have their merits, but the granite rollers are excellent for all-round work and preferable for heavy grinding. In this respect both the granite and porphyry rollers fully justify the claims made on their behalf. The stone grips the pigment better than the metal, and the grinding is much more effectual in consequence. There are, moreover, still some colours in use which have a tendency to alter by over-much contact with metal, and here again stone rollers can claim the advantage.

There are grinding mills fitted with water-cooled steel rollers to counteract the effect of friction heat during grinding, a feature which will be discussed hereafter. Water-cooled rollers probably merit more consideration than they have yet received. Fig. 4. shows a modern type of ink-grinding mill. The rollers

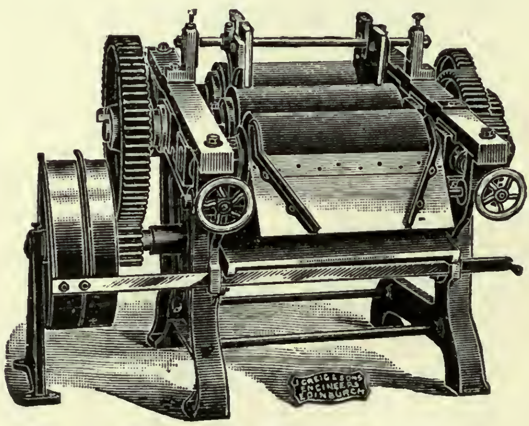

FIG. 4.

are usually geared to run at different speeds, and occasionally a lateral motion is arranged for the last roller.

Fig. 5. illustrates an entirely novel departure, of French origin, in which the motions of hand-grinding are cleverly reproduced. Printing inks can of course be ground by hand, but the operation is slow, laborious and comparatively unsatis-

factory. The procedure is quite simple and the apparatus required modest indeed. A fairly large mixing slab, palette and scraping knives and a stone grinding muller constitute a complete outfit for hand-grinding. The following brief description will justify the observation concerning the simplicity of this operation: Place some dry colour on the slab and mix into it sufficient thin varnish to form a stiff, pasty mass. Spread a little of this across the slab and grind it very thoroughly under the muller. Scrape up the ink and repeat the operation again and again until every vestige of its original granular texture

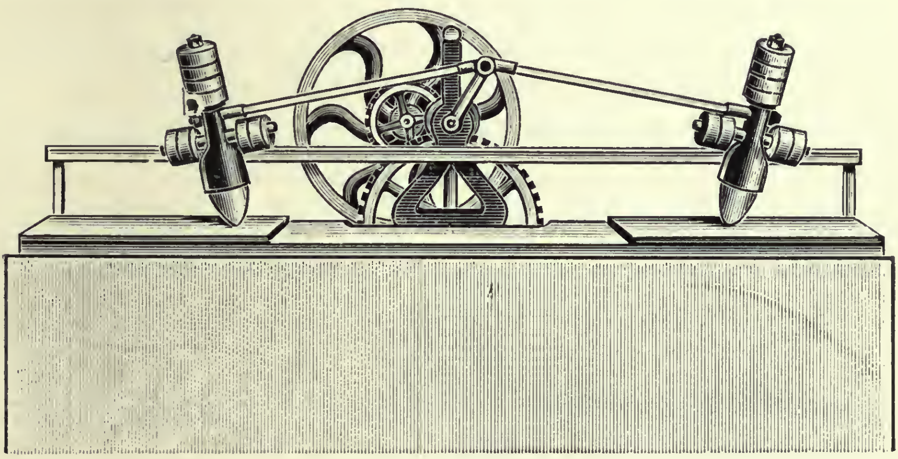

FIG. 5.

has disappeared. This condition can be ascertained by passing the palette knife lightly through the pigment, when it should appear bright and perfectly smooth. It should always be remembered that no amount of mixing alone will produce this result. It must be consistent and forceful grinding, which is, as already remarked, a long and laborious operation. Some dry colours are exceedingly hard and gritty in texture. When this is so they should be reduced to a fine powder before being mixed with the varnish previous to the grinding. Special machinery has been constructed for this preparatory work, but, unless very large quantities of material are required, the powdering can very well be accomplished by passing the dry colour through the ordinary ink-grinding mill with the rollers adjusted to a fair pressure. Fineness, and what is sometimes most expressively described as tenderness of the powdered materials increase their lustre or fire when they are subsequently converted into pigments.

Some printing ink makers prefer to soak the hard, gritty colours in alcohol for a day or two, and then, after grinding them to a powder, they are mixed and then ground with varnish in the usual way. This powdering will make the combination of dry colour with varnish much easier and more effective. Before the actual grinding begins, the dry colour should be roughly mixed with a little varnish. This can be done in any convenient manner, just so that the dry material becomes partly saturated by the varnish so as to facilitate the grinding, during which the remainder of the varnish is added as required. An ink-grinding mill is not usually an effective mixing machine, and this preparatory mixing is best at all times. For mixing purposes one or more large stone slabs are useful, also for each grinding mill two strong and deep trays will be required to catch the ink as it leaves the scraper.

It has been suggested by a recent writer that when a statement is made in a book that "it is difficult to state the proper constituents of printer's ink, you may be sure that the author is a cautious man". Well, it behoves a technical writer to be cautious in making precise statements, and in this particular it would be difficult to give definite proportions of medium or varnish and dry colour for the manufacture of printing ink, and for very good reasons. Take the varnish as an example. There is no standard of viscidity for any given gradation of varnish, consequently a gallon taken from one batch might carry as much dry colour as one and a half gallons of varnish prepared by a different manufacturer, or by the same maker at another time. Even the age of varnish will change its character to such an extent as to alter its value in a question of proportions. Then again grinding has an important influence upon the proportions of dry colour and varnish required for printing inks. Also atmospheric conditions, the work for which the printing ink is required, and the price at which the pigment must be manufactured will all materially affect proportionate quantities. How then can it be possible to state precise proportions?

For approximate calculations the following particulars may be useful, but the factors already mentioned are invariably influential and compel consideration. For a letterpress printing black of a fairly good quality, one gallon of medium varnish will be required to grind up from two and a half to three pounds of dry black. These proportions, however, must necessarily vary according to the character of the materials used. In the description of blacks (see chap. v.) it has been shown how a variation in the quality of printing inks is caused by a serious disturbance of proportions.

A little yellow soap (not soft soap) may, with advantage, be ground up with letterpress printing inks. Soap helps the ink to distribute freely on the printing machine, and also has a tendency to prevent its accumulation on the face of the types. In other words, soap makes the printing inks "lift" freely and comfortably. One pound of soap to each gallon of varnish, or to about every twelve pounds of printing ink, would be a reasonable proportion to use. This should be sufficient to make the ink work smoothly and without clogging the printing formes. The greatest possible care should be taken to mix the soap thoroughly with the other materials. A method of incorporation is suggested in chapter iii., and is probably the best to adopt.

In a former chapter it has been pointed out that, while some materials are quickly saturated by varnish, etc., other substances, on account of their crystalline character, are much less absorbent, and their combination with the vehicle is, for a time at least, little more than mechanical. This feature sometimes leads to a serious error of judgment in the grinding of printing inks. When the inks leave the grinding mill they are comparatively soft and free, yet in a few days they may become tough and unworkable. In the first place only a mechanical combination of the materials has taken place. Saturation and its consequent intimate combination is a question of time, when the vehicle may be overwhelmed and the ink become too stiff for convenient working. The remedy is of course simple enough—the ink must be re-ground and more varnish added to bring it to a reasonable working consistency; but the fault is usually found after the ink reaches the customer and too late to apply the remedy suggested. Experience alone can control this matter; it is advisable therefore to note carefully the peculiar traits of various inks under the conditions indicated. The possibility or rather the probability of such a contingency fully justifies the argument already put forward, that the printing ink manufacturer should be well acquainted with the characteristics of the materials he uses, so that he may utilise their peculiar qualities to the best possible advantage.

Another frequent error of judgment in the grinding of printing inks, and one which produces results similar to those described in the preceding paragraph, is when an insufficient allowance is made for friction heat. The power exerted between the rollers of an ink-grinding mill when working, and the character of the materials treated, generate a great amount of heat. Consequently the printing inks thin out during grinding, only to stiffen again as they grow cool. To avoid the possibility of a mistake in this respect, the pigment may be tested from time to time by spreading a little on the mixing slab. This will cool almost immediately when its exact consistency can be ascertained.

In concluding this chapter it will be useful to remember that it is almost impossible to exaggerate the value of consistent grinding. The combination of varnish and dry colour must be as intimate as it is possible to make them. The following extract from the columns of an authoritative journal [1] is practical and suggestive in its reference to this point: "A pigment mixed with varnish and run once or twice through the mill will make a good poster ink—although even here there are advantages to be derived from thorough grinding—but would not print an ordinary line cut. The same pigment mixed with a better and stiffer varnish and more thoroughly ground would be useful for ordinary job work, but would not print a half-tone cut, not even a coarse one. Put it again and again through the mill until it has become reduced to impalpable particles, and thoroughly incorporated with the vehicle, and you can use it on anything which has to be well printed."

[1] *Progressive Printer.*

CHAPTER X.

INK AND COLOUR MIXING.

A Necessary Acquisition—Ink Mixing Defined—Mixed Green Inks—Mixed Brown Inks—Tints—Ink Mixing—Lithographic Inks—Characteristics of Yellows—Mixing Vermilion—Ultramarine and Other Blues—Bronze, Prussian and Chinese Blues—Working Consistency—Reducing Mediums—Letterpress Inks—Gloss Inks—Three-colour Inks—Ink-mixing Machine.

In the introductory chapter of this volume it has been pointed out that the printing ink manufacturer must have some knowledge of ink mixing for specific purposes, because it is by no means unusual for the printer to requisition from the manufacturer special inks or mixings for various processes, and to meet peculiar requirements. Ink mixing, of this description, is therefore well within the scope of the ink manufacturer's work. Although it is scarcely possible to anticipate every demand in this respect, the present chapter will include the most important features, and if read in conjunction with the chapter following, *viz.*, "The Characteristics of Some Printing Processes," will suggest many of the possibilities which are likely to be involved in the preparation of printing inks to meet the ever-varying requirements of the printer. Ink mixing may include (1) the blending of various colours to produce a variety of tones and shades, (2) the preparation of inks to fulfil peculiar conditions, referred to in the preceding paragraph as the ever-varying requirements of the printer.

The preparation of some of the green printing inks is perhaps the most notable example of what may be described as *colour mixing* to distinguish it from that other phase of the work, *viz.*, *ink mixing*. A green printing ink may be prepared by mixing together the two primary colours, blue and yellow, but there are many varieties of both these colours, and the point of chief importance is to choose those colours which are most suitable, and that of course entirely depends upon the tone of green required. For example, ultramarine blue would be altogether useless for the production of a bright green, because the hue of that blue inclines to purple, whereas Chinese blue, Prussian blue and bronze blue all have a greenish hue and are therefore suitable for the preparation of a brilliant green ink. The same argument may be applied to the yellows, and to every phase of colour mixing. Chinese, Prussian or bronze blue when mixed with cadmium yellow will produce an excellent green. Some of the chrome yellows may be substituted for the cadmium yellow, but the yellow ochres and Naples yellow have an orange tinge and are therefore not so suitable for the preparation of bright greens. If, however, the green colour to be produced is of a subdued tone, sometimes described as an "art shade," then the warmer blues and yellows may be employed. These references are to the mixed greens and not to the manufactured pigments, such as "Terre Verte," "Zinc Green," etc., which have been discussed in another chapter.

Some of the brown printing inks are prepared from natural earth colours, without any additional colouring matter whatever. Then again some browns consist of these earth colours "toned up" with supplementary colorants to produce the hue required, but very many of the brown printing inks are prepared by colour mixing. A simple brown can be made by mixing together black and vermilion, and this can be toned up or changed to a variety of hues and shades. The addition of crimson or scarlet lake will make the colour more brilliant and fiery; blue will give it a colder purple tone; yellow will change it to a golden brown, and the addition of white will alter the shade to any strength required.

The natural earth colours may be varied in shade or tone in a somewhat similar manner, so that a considerable range of brown printing inks are available if needed.

Tints of the various colours are frequently required by the printers, but as these are mostly for special purposes, which vary continually, it will be valueless to discuss them excepting on general lines. In the absence of definite colour standards or copies, it will be impossible to state either the colours or their proportions for the mixing of tints, even though such tints be of the simplest possible description. Pinks might be of crimson or scarlet hues, and blues have even a wider range of inclination. A simple grey may be produced by mixing together black and white only, but here again the variations are almost unlimited. Warm or cold hues are imparted to greys by the addition of red or red lake and blue respectively. A touch of yellow also produces a useful variation. Flesh tints are not quite so extensive in their variety, yet the slightest change in hue or tone may be effected at will. Vermilion, yellow and burnt sienna, in suitable proportions, are the colours generally used for flesh tints. The colour copy must of course decide these proportions. Transparent tints, *i.e.*, tints with a varnish body, are usually the most satisfactory for printing purposes. They are brighter and often cleaner than tints with a body of opaque white.

There are numerous other blendings of the various colours used in printing, but they are chiefly special arrangements to suit particular purposes for which they may be required. Within the limits of a single chapter it would be well-nigh impossible to discuss in detail the innumerable possibilities of colour mixing, but the foregoing descriptions may be regarded as characteristic examples. A keen perception of colour tone and strength, wedded to a little practical experience, are the all-important factors in colour mixing.

Ink mixing like colour mixing requires the closest possible attention on the part of the operator. All pigments have their peculiarities, and their successful application to the various purposes for which they are used demands a liberal expenditure of skill and care. These two attributes a text-book cannot bestow upon its readers. It can, however, emphasise their necessity and possibly inspire their fulfilment. Ink mixing, as applied to the preparation of printing inks for specific purposes, requires a somewhat intimate knowledge of the various printing processes to ensure satisfactory results.

Here and there, in this volume, characteristic requirements have been pointed out and discussed, yet there are still others which merit consideration. The following descriptions of the more important features of some printing inks, viewed from a printer's standpoint, and taken in conjunction with the work for which they are intended, will be useful and suggestive to the ink mixer and helpful also to the manufacturer.

The first few references are almost exclusively applicable to lithographic printing, because for reasons already given (see chap. iii.) the different characteristics of many printing inks are more important and influential in their application to lithographic than to letterpress printing. At the same time many of the features to be discussed have a general application. Yellow printing inks are sometimes very troublesome, and in a variety of ways. Occasionally the varnish separates from the dry colour soon after printing, and leaves the latter on the surface of the paper. A most disastrous occurrence, for not only does the unattached powder rub off with the lightest touch, it also presents an impossible printing surface for any subsequent impressions. Insufficient grinding or incomplete saturation may cause this trouble, but it is nevertheless a physical characteristic of the materials used in the manufacture of most yellow printing inks, and may be remedied by the liberal employment of a strong or even an extra strong varnish. If driers are added to a yellow printing ink which is used as an early printing in a series of colours, some difficulty may be experienced with subsequent printings. The dry yellow ink becomes hard and presents an unsuitable surface for the superposition of other colours, therefore the addition of driers to yellow should be avoided as far as possible. Some yellows display a considerable amount of acidity during printing, in consequence of which the finer parts of lithographic work are frequently destroyed. This acidity may be counteracted by adding to the ink a very little Russian tallow, about half an ounce to the pound of ink, or a small portion of stearine. The tallow or stearine should be melted with a little varnish and then quickly incorporated with the printing ink before it has time to re-solidify. It is important to remember that in whatever way a yellow printing ink may have to be manipulated, a fair degree of tenacity or viscidity should always be maintained.

Vermilion is an exceptionally heavy printing ink, and probably the heaviest pigment used by the printer. It has a flaky or patchy tendency during printing, and particularly in lithographic printing, when the motion of the rollers, together with an almost continuous contact with moisture from the lithographic stone, partly destroys the coherent character of the ink. This usually results in a separation of the dry material from the varnish in which it is ground. It is therefore advisable to maintain a certain amount of tenacity, as with the yellow inks already discussed, but not to such an extent as to interfere with its mobility. In fact some softening medium may occasionally be required to enable this dense printing ink to work freely when a little tallow may be used, but only a very little, lest the ink become too loose and greasy, and in such a condition successful manipulation is very difficult and the impression produced is unsatisfactory.

Ultramarine blue, oriental blue and royal blue require careful preparation to adjust the exact balance of colour, strength and working consistency. Some strong medium must certainly be added to these inks to impart cohesion and homogeneity, otherwise the impression, when printing, will be mottled or patchy. On the other hand, the colour-strength of these blues is easily depreciated, and any extensive addition to their bulk will immediately affect their colour value. Strong varnish will give the requisite cohesion, but it may also make the inks too tenacious, when a softening medium would be required. This of course involves additional bulk, which is undesirable. A preparation usually known as "waxed varnish" is recommended as a suitable addition to ultramarine and other similar blues. This composition may be prepared in the following manner: Melt into one pint of thin lithographic varnish six ounces of paraffin wax and two ounces of white (dry) stearine. See that the materials are thoroughly mixed together before the composition is allowed to cool. This preparation will keep for a long time, and may be advantageously used in ink mixing generally. The quantity required will vary according to the consistency of the printing ink with which it is mixed. The idea is to make the ink soft and mobile and yet keep it reasonably firm.

Bronze blue, Prussian blue and Chinese blue possess characteristics which are very different from the blues already discussed, and must be treated accordingly. There is a peculiar lack of cohesion in this range of printing inks, a feature which is distinctly troublesome in lithographic printing and must be remedied. They also possess energetic drying qualities, concerning which some degree of depreciation is usually required. A little strong varnish should always be used when preparing these inks for printing, and the use of thin varnish is almost, if not entirely dispensed with. A small quantity of Canada balsam is exceedingly helpful when reducing these blues to a working consistency. Although sometimes regarded as a drier, Canada balsam does not oxidise very rapidly. It has just sufficient tenacity to bind together the loose particles of any ink with which it may be incorporated, yet it works freely and comfortably. In mixing these blues for printing the points requiring most consideration are their lack of cohesion, in consequence of which they may become "sloppy" and unmanageable, and their emphatic greasy tendencies which cause scum and endless trouble. A remedy for lack of cohesion has already been suggested. For scum and grease it may be necessary to add to the printing ink some inert but absorbent material such as magnesia or very finely powdered whitening. These will absorb any excess of grease in the inks referred to, but if used to any extent will lower their colour value. These descriptions do not by any means cover the full range of inks used by the lithographic printer, but they include the more difficult preparations and are sufficiently indicative of average requirements.

"The chief requisite in colour printing," according to a well-known practical worker, "is the production of a solid, flat impression, and for this purpose almost all inks must be reduced to a suitable working consistency. To accomplish this, and at the same time retain the full colour-strength of the printing ink, a soft, free-working composition is desirable." There are several varieties of solid oil from which the excess of grease has been extracted. These form excellent reducing mediums. They break down the harshness of stiff pigments, and enable them to work freely during printing. There is a reasonable explanation of this which is interesting and suggestive. Whatever the character of a reducing medium may be, its effect upon the strength of a colour will be in proportion to the quantity used. In all probability one ounce of a solid oil composition would soften down a quantity of printing ink for which at least three times its bulk of varnish would be required. Consequently, the depth of colour and covering power of an ink reduced with solid oil, or any similar medium, will be proportionately greater than that reduced with varnish. Petroleum jelly, in some of its commercial forms, may be used as a reducing medium for printing inks, but with all reducers of this class care and judgment must always be exercised, lest there should be a loss of cohesion in the pigments treated. Letterpress printing inks are usually manufactured of a consistency suitable for normal working conditions, and further preparation is seldom required. One notable exception in this respect is the printing inks for High Speed Rotary Printing. These are principally blacks, and they must possess an exceptional degree of mobility. Yet they must not be at all "sloppy". It is not sufficient, as sometimes suggested, to increase the proportion of varnish and decrease the quantity of black in the original preparation of these inks. Some softening medium must be incorporated with the pigment—a very little tallow, or some solid oil as recommended in the preceding paragraph. The chief requisite is perfect mobility. Gloss inks, *i.e.*, printing inks which are intended to dry with a brilliant gloss, are occasionally required, and it is well to know something about them. These inks should, as far as possible, be mixed with the stronger varnishes so as to retard their absorption by the paper. A little quick-drying copal varnish should also be mixed with gloss inks and also a liberal allowance of some energetic drier. The point is to keep the ink on the surface of the paper, and on no account whatever must the softening mediums be used. The consistency of three-colour inks, for photo-mechanical tri-colour work, is usually such as will require but little if any variation when used at the printing machine. The more important features of this work will be fully discussed in another chapter.

Where printing inks require mixing in large quantities the ink-mixing machine shown in Fig. 6 is very useful. This machine considerably reduces the physical labour of the operation, and effectually breaks down the stiffer inks to any consistency which the exigencies of the work may require.

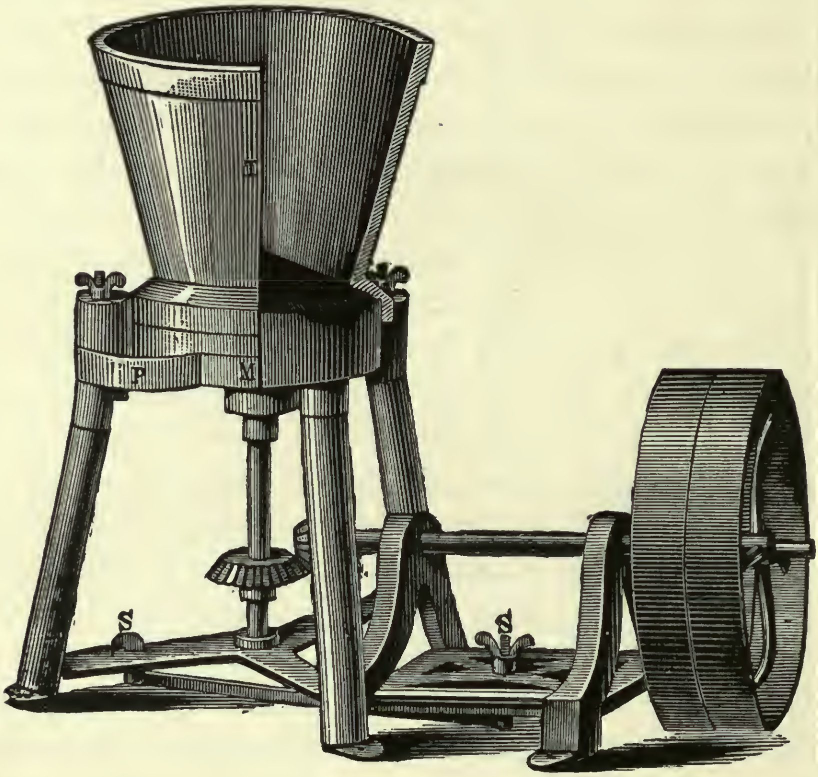

Fig. 6.

The reference to friction heat, in the chapter on the "Grinding of Printing Inks," may also be applied to ink mixing by machinery, and the same precautions must be observed when deciding a point of working consistency.

CHAPTER XI.

THE CHARACTERISTICS OF SOME PRINTING PROCESSES.

A Supplementary Discussion—Letterpress Inks—Three-colour Printing—Lithographic Printing Inks—An Important Feature—Suggestive Points—Tin-plate Printing.

In the introductory chapter of this volume an emphatic reference is made to the numerous processes for which printing inks are required, and also to the variety of conditions under which they are employed. Here and there in the text this reference has been amplified, and, to some extent, several characteristic features are explained. The chief object of this chapter will be to complete some of these explanations, and to discuss other important features which directly influence the manufacture of printing inks. These descriptions of "The Characteristics of Some Printing Processes" may also be regarded as a sequel to the preceding chapter, and though in many respects deliberately digressive, they will undoubtedly supply the printing ink maker with much necessary information, and by doing so probably indicate ways and means for the more effective employment of materials at his disposal.

The preparation of inks for general letterpress printing will seldom give the ink manufacturer serious trouble. The printing operations are completely mechanical, and although possibilities of mishaps are by no means remote, their character does not often place them beyond the control of such remedial measures as are discussed in various parts of this volume. The better class letterpress printing inks require much thought and care in their preparation, chiefly because of the extreme fineness of many of the printing formes, and the high speed at which letterpress printing machines are frequently worked. It is important that the base of the finer letterpress printing inks should be as light as possible, and even the lower grade inks should receive consideration in this particular. A pigment with a heavy base would quickly fill in the face of small type in common use, while the extremely fine process engravings would never give a clear impression. For example—the carbon blacks are exceedingly light, while many of the mineral blacks are much too heavy for the manufacture of printing inks. The former have sufficient density for all practical purposes and possess considerable staining power. They are therefore suitable as a base for printing inks. The latter process has an unrivalled density and covering power, but unfortunately their peculiar composition prohibits their employment, excepting in very small proportions, for the preparation of printing inks of any kind.

"Three-colour printing" is a comparatively modern development of the graphic arts in which the problems presented are by no means easy to solve. The three primary colours in nature and the three primary colours in pigments are far from being in perfect accord; consequently three-colour reproductions may be excellent approximate representations of nature's colours, and, as such, are generally artistically effective, but they are not facsimile copies. A first essential is to produce three neutral printing inks, *viz.*, yellow, red and blue, which will, as nearly as possible, match these several colours of the spectrum. A yellow which has neither a leaning towards green nor red, a red without orange or blue tendencies, and a blue without a suspicion of either green or purple hues. A yellow which, when mixed with blue, will produce a brilliant green will not usually give the best orange effect when mixed with red, and similar experiences are associated with the other primary colours. A blue intended for mixing yellow for a bright green will be of little value in combination with red to give a rich purple, etc., etc. Even with the full range of aniline dyestuffs at his disposal the printing ink maker must be satisfied with approximate effects, and to obtain these there must be a considerable sacrifice of permanence in the pigments. The brightest of the aniline colours are fugitive when exposed to strong daylight.

From the foregoing arguments it will be readily concluded that it is largely a question of suitable selection as far as the actual colouring materials are concerned. In every other respect the three-colour printing inks are high-grade letterpress inks with which a rich, full-bodied impression can be made with a minimum feed of ink on the printing formes. Tri-colour inks are usually prepared of a consistency which will require but little if any variation when they are used by the printer. If it could be made commercially convenient an ideal preparation of three-colour inks would be one in which the hue of each of the three-colour pigments would be in perfect agreement with the colour screens used for the photo-mechanical reproduction of work for which the printing inks are required. Such an arrangement is not by any means impossible, but obviously inconvenient. The chief points to be kept in mind when selecting colours for tri-chromatic printing inks are purity of tone, luminosity, and, as far as it can be obtained, neutrality.

In chapter iii. there is a brief reference to the theory of lithography in which it is very clearly pointed out that the maintenance of a perfect balance of the two attributes, grease and water are the influential features which must control the preparation of all lithographic printing inks. As already pointed out, an effective control is largely effected by the employment of a suitable varnish. Another important feature of good lithographic printing inks is intensity of colouring power, so that when printing, a maximum of colour-strength can be produced with a minimum quantity of pigment. In lithographic printing, once the paper is completely covered by the printing ink, *i.e.*, when the impression is full, firm and flat, the most comfortable printing conditions will invariably be when the minimum bulk of pigment is employed, and to this end the printing ink should possess great colour-strength. The reasonableness of this argument will be apparent even to the uninitiated reader. As far as possible, lithographic printing inks should be free from acid. The lithographic stone is a comparatively soft homogeneous limestone, which is readily decomposed by most acids, and decomposition of the surface of such a stone involves a deterioration and eventually a destruction of the work thereon. Lithographic printing inks should not have in their composition a colorant which is likely to be in the slightest degree soluble in water. Water is naturally an essential feature of lithography, and where soluble colorants are concerned—as in some of the lake pigments—a stain or scum rapidly develops during printing, causing a considerable amount of trouble and frequently soiling the paper to a serious extent.

There are, of course, many features of lithography which compel the interest of the printing ink maker, but most of these have been discussed in direct association with the pigments influenced by them. One, however, still awaits consideration. Tin-plate printing is entirely lithographic, and differs from lithographic paper printing chiefly in its mechanical application. This difference, however, is important because it materially affects the character of the printing inks required inasmuch that beyond a certain point it is impossible to increase the *weight* of colour in the impression. In lithographic paper printing it is possible, and frequently advisable, to increase the weight of colour, *i.e.*, ink, in the manner referred so as to obtain a stronger colour in the impression. In tin-plate printing, owing to peculiar mechanical conditions, the maximum of colour-strength must be produced by a minimum of bulk, as far as the printing ink is concerned. The obvious conclusion is that tin-plate printing inks must be of the best possible quality so that the conditions, already indicated, may be more or less completely fulfilled. Of the various inks used for tin printing white is the most important. A solid white ground almost invariably constitutes the first printing, and this must be of sufficient opacity to completely cover up the metallic lustre of the tin-plates, otherwise it will present a decidedly grey appearance, and the colour values of all subsequent printings will be very much depreciated. For the same reason these white inks must be permanent, *i.e.*, they must not appreciably change colour when varnished and stoved at a high temperature, approximately 140° Fahr. For the preparation of this printing ink a zinc white is usually more reliable than lead white. All tin-printing inks must be proof against stoving at the temperature indicated above. In this respect reds are the most unreliable pigments. The lighter blues also require careful selection, but the whole matter may be successfully controlled by a little experience and careful observation.

CHAPTER XII.

DRIERS.

A Valuable Auxiliary—Energetic Drying Inks—The Theory of Drying—Liquid Driers—Terebene—Paste Driers—Letterpress Driers—Powder Driers—Turpentine as a Drier.

In association with the manufacture of printing inks, as with many other industrial concerns, there are side-issues which may or may not have a direct connection with the main interest. Occasionally these side-issues are valuable auxiliaries, and in the making of printing inks one of the most important of them is driers. The preparation of driers is usually undertaken by the printing ink maker. He may sometimes require them for his own use, and they will almost certainly be requisitioned from him by the printer. Several of the printing inks, notably the bronze, Prussian and Chinese blues, dry very quickly, but, on the other hand, most of the inks employed by the printer dry much too slowly for average requirements. Under such circumstances it is usual to mix with the printing inks a suitable accelerator, of which there are many varieties, both liquid and solid.

The theory of drying, in its application to colour pigments, is exceedingly simple yet suggestive. A brief outline of this theory will interest and help both the manufacturer and the user of printing inks. Elaine is the non-drying element in all pigments compounded with linseed oil or its products, and so long as this elaine remains free the olein in the pigment will oxidise and dry very slowly indeed. The metallic base of a prepared drier takes up or neutralises whatever elaine there may be in printing inks, or any other similar pigments, and sets the olein free for immediate oxidisation. When no drier is added, the elaine evaporates in course of time, but very slowly, and until this takes place the olein will not oxidise and the printing ink will not harden or dry. The prepared or added drier may therefore be described fitly as an accelerator.

Of the many drying preparations favoured by the printer "liquid driers" require the most careful manufacture. Metallic compounds are dissolved in linseed oil or oil of turpentine, and unless a perfect combination of these materials takes place there will always be the possibility of subsequent separation and a consequent deposit of the heavier substances. The most important point in the preparation of liquid driers is a persistent boiling of the materials, so that the heavy oxides, or whatever may be the metallic compounds used, will intimately combine with the liquids and not be only held in suspension by them. A liquid drier commercially known as terebene is safe, effective and convenient to use with printing inks. Terebene is an energetic drier, and only a very little of it need be added even to the soft, greasy printing inks, so little indeed that it produces no perceptible alteration in the bulk or character of the ink. One of the simplest formulæ for terebene is as follows :—

1 gallon linseed oil.
$1\frac{3}{4}$ lb. lead oxide (litharge).
$\frac{1}{2}$ lb. acetate of lead (sugar of lead).

Boil these materials together for two or three hours until a few drops become stringy when cooled, then thin down to the consistency required with from $1\frac{1}{2}$ gallon to 2 gallons of oil of turpentine.

Of the several forms of paste driers that known commercially as "patent white" is the most satisfactory. The following is a description of its preparation :—

Formula.

24 lb. Paris white.
20 lb. barytes.
1¼ gallon raw linseed oil.
1 lb. sugar of lead.
4 lb. powdered litharge.
5 lb. zinc sulphate.

Mix the sugar of lead, litharge and the zinc sulphate with about two-thirds of the linseed oil, and allow them to stand for three days. Then mix this preparation thoroughly with the remainder of the oil. Finally grind in the Paris white and barytes and allow the composition to mature for at least fourteen days before using.

A powerful drier prepared according to the following formula is generally used for letterpress printing inks only. It is somewhat severe in its action, and has a slight tendency to darken delicate or light colours:—

12 lb. copperas.
12 lb. sugar of lead.
6 lb. litharge.

A powder drier is not usually required by the printing ink manufacturer. It is just possible, however, that at some time it may be called for, when the following formula will be useful:—

Mix thoroughly together

6 lb. zinc white.
6 lb. lithopone.
4 lb. manganese borate.

Pass this several times through a fine sieve to ensure perfect mixing.

Powder driers are not nearly so convenient to use in connection with printing inks as the paste driers, and in the majority of instances the liquid driers are cleaner and more effective than the paste driers. It depends chiefly upon their peculiar suitability for the work in hand, a point which cannot be defined by "rule of thumb". For a more extended study of driers and drying an exceptionally comprehensive work by L. E. Andés is recommended—*Drying Oils, Boiled Oils—Solid and Liquid Driers.*

In the strict sense of the term turpentine is a drier, *i.e.*, an oxidiser, for it will absorb oxygen in a remarkable manner; moreover, it possesses a peculiar and valuable characteristic, for it has the power to convey the oxygen it has absorbed to materials which do not readily oxidise themselves. There is some degree of uncertainty as to the actual chemical change which takes place, but that, in the present instance, is scarcely material. The point of importance is its value as an oxygen carrier. Turpentine substitutes, however much they may resemble the genuine article in other respects, have not this power of absorbing and conveying oxygen. Turpentine substitutes may be composed of products which, owing to their volatile character, evaporate readily, but such volatile materials will not oxidise themselves and cannot therefore convey oxygen to other substances. This is a point of much importance to the printing ink maker, since it is quite obvious that these substitutes for turpentine are practically valueless for manufacturing purposes, and particularly as ingredients of the liquid drier described in the earlier part of this chapter.

CHAPTER XIII.

BRONZE POWDERS AND BRONZING.

A Brief Justification—Bronze Printing Inks—Bronze Powders—The Process of Manufacture—Preparation of the Leaf—Grinding and Grading—Bronzing Mediums—Requisite Qualities—Wax Varnish.

THE inclusion of this chapter is in accordance with the plan outlined in a preceding one, wherein the necessity for complete and comprehensive knowledge was emphasised; a plan which has been insistently followed throughout this volume, and occasionally carried even to a point of digression. Only a very few of the printing ink makers are manufacturers of bronze powders, but all are interested in them, for they are in many respects closely allied with printing inks. Regarding this matter from quite another standpoint, even though the preparation of bronze powders may not directly interest the ink maker, the information afforded by a detailed description of their manufacture may assist in the solution of that somewhat hoary problem—the preparation of a satisfactory gold or silver bronze printing ink. There can be no doubt whatever as to the value of such an ink to the printers—both lithographic and letterpress—but the physical peculiarity of the metallic base presents a very real difficulty. No amount of mixing and grinding will produce a pigment of sufficient smoothness to work freely on the printing machines. In letterpress printing the type faces very quickly "fill up" with such an ink, while in lithographic printing the impression is thick and coarse because of the gritty character of the ink under discussion. These effects are largely due to the fact that most dry colours are, in a measure, saturated by the vehicle with which they are incorporated, in addition to such a mechanical combination as may be produced by grinding. With metallic bronze powders only a mechanical combination is possible, and there cannot be any appreciable *saturation*. There is also one other point worth noting—the brilliant lustre of metallic powder is partly destroyed by the vehicle, *i.e.*, the varnish in which it must be ground to form a printing ink.

Returning now to a consideration of bronze powders, it is interesting to know that the idea originated with a monk at Fürth in Bavaria about 300 years ago. It can scarcely be described as an invention. It was simply an economical application of the waste materials, the scraps and cuttings of the metallic leaves known as "Dutch leaf". These metallic leaves were used for the ornamentation of parchments, and no doubt the bronze powders were used for the same purpose. For very many years, and, in some instances, even yet, the fragments—the scraps and cuttings of "Dutch leaf"—are used for the preparation of bronze powders. Copper and zinc are the original materials for the manufacture of bronze powders; no matter whether they are prepared from the metals in a state of purity or from the scraps of leaf, as already described. In reality, then, bronze powders are finely powdered brass, for brass is an alloy of zinc and copper, and it is possible to change the tone of the powder somewhat by a variation of the proportions of the two metals involved.

The process of manufacture naturally divides itself into two parts, *viz.* (1) the hammering out of the alloy into leaves, and (2) the grinding of the leaf metal into fine powder. In both operations long experience and incessant care are essential factors. The various processes are slow and even tedious, consequently the cost of production is comparatively high. The manufacture of bronze powders was started as a means of utilising waste material, but very soon the demand far exceeded the supply of such material available, consequently the manufacture of leaf-metal developed on a large scale, and chiefly as a material for the preparation of bronze powders. Copper and zinc are melted together in crucibles and afterwards moulded into ingots about half an inch thick and two feet long. These ingots are cold-rolled under heavy pressure, the operation being repeated again and again, until the metal is drawn out into a thin ribbon about one inch wide. At this stage the metal requires annealing and afterwards cleansing from impurities in an acid bath. When cut into suitable lengths it is laid between sheets of zinc and passed under powerful hammers until the strips or ribbons are reduced to the thickness of tissue paper. During the hammering operations the metal is repeatedly cleaned by immersion in a bath of tartarate of potassium. After careful assortment the metallic leaves are cut into squares, made up into bundles and enclosed in brass envelopes or covers. Then follows another annealing process and more hammering, until the metal is reduced to a thickness, or rather a thinness suitable either for decorative purposes as a leaf, or for reduction to the bronze powder of commerce.

The small sheets or leaves of metal, when withdrawn from the brass envelopes, are cut up into small pieces and rubbed through a fine sieve together with a little olive oil. The subsequent grinding requires three or four hours, after which the oil is removed from the powder by the application of heat under heavy pressure. Grading machines are used for dividing the powder into its several qualities. These machines are of the simplest possible construction. They are arranged so as to expel the bronze powder through fine holes into a compartment with shelves fixed at different altitudes, when of course the finer particles settle on the higher shelves and the coarser particles on the lower.

It may not be seriously out of place to conclude this chapter with the description of a suitable bronzing medium, *i.e.*, a medium or preparation by which the bronze powder may be firmly attached to the paper without in any way depreciating its brilliancy. Of the many preparations which the printing ink maker may be called upon to supply, a reliable bronzing medium claims an important place. The bronzing operation does not suggest any unusual difficulty in this respect, yet a considerable amount of care and discretion must be exercised in connection therewith. The procedure is simple: An impression from the printing forme is made on paper with a tenacious ink or some suitable preparation, after which the bronze powder is dusted on. The care and discretion must be chiefly directed to the medium, *i.e.*, the ink or preparation. The three most important considerations in the preparation of a bronzing medium are tenacity, neutrality and colour. Tenacity may be secured by the use of strong and extra strong varnishes, but then the surface of the paper is not always sufficiently strong to bear the drag of an unusually strong ink when the impression is made. On the other hand, should the bronzing medium be softened down to meet the deficiencies of the paper, the softer particles of the preparation will immediately be absorbed, leaving an insufficient quantity to hold the bronze powder. A useful base for a bronzing preparation is a wax varnish, *i.e.*, a good lithographic varnish with beeswax melted into it until it is about the consistency of lard or tallow. Such a varnish is at all times firm yet soft. It holds the bronze powder firmly, dries reasonably well, and gives a clean impression.

So much then for tenacity. Neutrality is chiefly influenced by the colouring materials employed, so that we may conveniently consider neutrality and colour at the same time. The point is to choose colouring materials which will not chemically react on the metal. The neutral earth colours are useful in this respect. Burnt umber, burnt sienna are neutral colours and especially helpful for gold bronze work because when mixed with a little yellow they are nearly of the same colour as the bronze itself. They will not therefore depreciate the brilliance of the metallic powder, and also if, by some mischance, a small portion of the impression is not completely covered by the bronze powder, the defect will not be seriously noticeable. The foregoing notes will no doubt be sufficiently suggestive to indicate the lines upon which a satisfactory bronzing medium may be prepared. Drying qualities must of course be arranged for, but their energy will depend upon climatic or local conditions.

CHAPTER XIV.

"THINGS WORTH KNOWING": A RECORD OF NOTES AND EXPERIENCES.

THESE "Things Worth Knowing" in most instances bear an intimate relation to the manufacture of printing inks, though certain items may appear to have only a secondary interest. They are culled from various sources and experiences, and are offered chiefly as auxiliary information in amplification of the text. Regarded from this standpoint they will serve to fill in many unavoidable intervals, and afford opportunities for explanations which might otherwise have been omitted. No attempt has been made to secure even a semblance of sequence in this collection of items. They are copied from the writer's notebook very much in the order of their entry.

Refreshing the eye after colour strain.—To refresh the eye when dealing with colours, look at green before red, red before green, blue before orange, orange before blue, violet before yellow, yellow before violet. By means of these refreshing contrasts it will be possible for the eye to detect the slightest variation of hue in any of the colours referred to.

Toning blacks.—Prussian or Chinese blue added to black printing inks completely destroys that brown tone which is peculiar to some of the lampblacks.

Soap in printing inks.—The properties possessed by soap as an ingredient of letterpress printing inks are, that it causes the ink to adhere uniformly to the face of the type, it covers the printing forme completely with the smallest possible quantity of ink, and it enables the ink to leave the type clean so as to produce a good impression.

Dry colour.—Dry colour for the preparation of printing inks should be in fine powder and free from moisture.

Grinding printing inks.—" The finer an ink is ground the greater number of square inches of paper it will cover with a full colour. A pound of ink in which the particles are ground twice as fine as another sample pound will cover more than three times as much surface and yet show the same colour to the eye, the pigment being of the same basis weight." " In finely ground ink the real colour of the pigment is brought out much more fully, and the colour will be richer and brighter although there is considerably less of it on the paper."

Earth colours and moisture.—The earth colours, described in a preceding chapter, sometimes become lumpy when exposed to moisture, and the lumps usually dry very hard, so that it is necessary to break them down again into a powder before grinding with varnish, etc.

Impurities in varnish.—When a composition varnish has been prepared, or any varnish preparation which is likely to deposit impurities, the final production should be kept as warm as possible for some time. In this condition the viscidity of the varnish is reduced, and the heavy particles of foreign matter more readily sink to the bottom and leave the preparation clear.

Suggestive facts concerning linseeds.—Linseeds are generally reasonably pure, but other seeds are unavoidably harvested with them. The percentage of these foreign seeds varies considerably both in bulk and character. For example, some of the Indian and South American linseeds show only about 5 per cent. of foreign seeds mixed with them, and these are almost exclusively non-oleaginous. On the other hand, the Baltic linseeds contain 10 per cent. to 20 per cent. of so-called impurities, but these are all more or less oil-bearing. North

American seed is like the South American varieties, comparatively pure as regards mixture with other seeds, but the foreign element is seldom oil-bearing, and the percentage of impurities must be reckoned accordingly.

Character of linseed oils.—Chemical tests have shown that the Baltic seed oil is hardest. Hydrometer test 29° to 30°. Other Russian oils are only a little softer. Indian and American oils are frequently too soft to be of any value to the printing ink manufacturers. In the chapter on "Varnish, etc.," Baltic oil is indicated as the only variety suitable for making printing varnish.

Boiling-point, etc., of linseed oil.—Linseed oil boils at 130° Centigrade. Vapours rise at 210° and ignite at from 360° to 400° Centigrade.

Chemical purification of linseed oil.—Permanganate has a quick and effective purifying action upon linseed oil. It destroys certain particles of foreign matter, particularly the cellular tissue, while at the same time it perceptibly bleaches the oil.

For 20 gallons of linseed oil dissolve 2 lb. of permanganate in $3\frac{1}{2}$ gallons of water. Stir this permanganate solution into the oil, and agitate the mixture frequently for three to four hours. Allow this to stand for two days, during which time the purified oil will completely separate from the water and may then be drawn off.

Rosin oil as an adulterant.—Rosin oil is the most common adulterant of boiled linseed oil. If a little of the suspected oil is rubbed between the fingers, the odour of the rosin oil is distinctly noticeable. In cold weather linseed oil adulterated with rosin oil becomes turbid, and the rosin oil shows a tendency to separate, a tendency which at once disappears on the application of warmth.

Rosin as an adulterant.—The cheaper forms of boiled linseed oil are sometimes thickened by the addition of rosin.

This of course adds to the viscidity of the oil, but it is a form of adulteration which is undesirable excepting for the preparation of the very commonest letterpress printing inks. The hardening qualities of the linseed oil and its products are impaired. A linseed oil varnish thus adulterated may remain sticky for an unreasonable length of time. If the suspected oil is exposed to light and air for twelve to fourteen days, the rosin will partly regain its crystalline form when its presence may be at once detected.

Adding rosin to linseed oil.—When it is desired to add rosin to linseed oil for thickening purposes, as in the manufacture of cheap newspaper printing inks, first break it up into very small pieces and melt them in a pan or boiler large enough to contain all the oil it is intended to thicken. Then when the rosin has been thoroughly melted over a slow fire, and has given off some of its vapours, the oil may be added. Heat slowly for thirty to forty minutes and stir frequently. If other ingredients have to be added they should be well incorporated with the melted rosin before putting in the oil.

Comparative permanence of colours.—A few years ago Sir W. Abney and Dr. Russell prepared a report on the action of light on colours, when an exhaustive series of tests enabled them to indicate very definitely the comparative value of various colours in this respect. The tests were made with water colours, yet the results are both suggestive and useful in their application to colours ground in varnish.

Prussian blue, cobalt blue, French blue, burnt sienna, raw sienna, terre verte, yellow ochre and chrome yellow remained unaltered after two years' exposure. Burnt umber, Antwerp blue and pure vermilion were only a little less permanent. Madder lake was reasonably permanent, while Naples yellow and carmine were decidedly fugitive.

Oxidising of linseed oil.—Comprehensive tests and experiments prove that linseed oil absorbs oxygen at first very slowly, and more rapidly once oxidisation has commenced. Linseed oil and its products, *i.e.*, varnishes, printing inks, etc., dry more rapidly when exposed to light and air than when exposed to air only.

Consistency of printing ink.—Printing ink should be so compounded that it may be applied to the printing forme in an infinitely thin layer. It should be sufficiently free to "lift" comfortably from the printing forme to the paper, and after the impression has been made there should be no greasy halo round the letters.

Colour mixing.—When the strength of a colour is problematical, or its effect more or less a question of experiment, it is a safe plan to mix it a little lighter than it will be required. For obvious reasons it is easier to alter the shade or hue of a light colour than of a darker one.

Descriptive terms used by printing ink makers.—In their classification of the various colours it is usual for the ink manufacturer to indicate their characteristics, especially as regards permanence. This enables the printer to make a satisfactory choice for any particular class of work, so that he may not unwittingly use a fugitive ink for work which will be constantly exposed to the light. The terms usually employed for this classification are:—

P. = Permanent.
F.P. = Fairly Permanent.
R.F. = Rather Fugitive.
F. = Fugitive.
V. = Varnishable.

The term "varnishable" indicates a printing ink which will not run or smear when coated with spirit varnish.

Some notes on turpentine.—Pure turpentine should be very nearly water white, yet this feature cannot be accepted as a reliable test for purity, because it is a powerful solvent and will therefore have a tendency to absorb any colouring matter which may be attached to the vessel in which it is stored. The chief adulterants of turpentine are mineral oils and mineral spirits. The following simple test has been suggested for the detection of mineral oils and the determination of their quantities: "Weigh out on separate watch-glasses 1 gramme of pure turpentine and 1 gramme of the sample under examination. Float the glasses on the surface of water maintained at 80° C. As soon as the pure turpentine has evaporated, weigh the two glasses. Deduct the weight of the pure turpentine residue from the weight of the other residue and the difference is mineral oil." It may be useful to know that the specific gravity of pure turpentine is about ·865. The specific gravity of petroleum spirit ·7306, petroleum ·7950, and paraffin ·8906.

Testing printing colours for permanency.—Some time ago at a chemistry congress K. Hazura recommended the following simple yet practical test for colour permanency: "Cover the surface, upon which the colour is printed, with black paper, so that at first only one square of the upper part of the surface on the left is exposed to the light. A week after another square of the lower surface on the left. Two weeks later a square of the upper surface on the right, and three weeks later a square of the lower surface on the same side are exposed to the light, so that the single sections are subjected to exposures for one, two, three and four weeks respectively." According to this authority, inks which showed no change after a four weeks' exposure to light may for most practical purposes be regarded as permanent. Those which stand the test for two or three weeks may be distinguished as fairly permanent, while such as fade within a few days may safely be classified as fugitive.

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(*See also Writing Inks, p.* 11.)

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(*See page* 28.)

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(*See "Evaporating, Condensing, etc., Apparatus," p.* 26.)

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