CHAPTER 8

Map and Plan Reproduction

After the detail and contours have been plotted the compilation sheet is taken into the field and checked for accuracy and completion. It is then passed on for the production of a number of copies of the finished map. The reproduction is carried out in the following stages—

1. Production of the fair drawing.
2. Preparation of the printing plates.
3. Machine printing, proofing (or proving).

Each of the three stages involves some form of printing.

Printing or the copying of a document can be done in four main ways—

1. Relief—Letterpress.
2. Intaglio—Gravure or Photogravure.
3. Lithography or Planographic Process.
4. Photographic Methods.

The first three all involve printing or proofing from a metal plate or stone surface. They differ in the methods of producing the plate, but since the proofing is similar for all three it is dealt with only under lithography.

LETTERPRESS

This is the method by which most modern books, newspapers and other periodicals are produced. It is particularly suitable for printing the written word. In this method, if it is required to print a line, the line will have to be produced standing proud on a metal plate. If a smooth roller is passed over the plate it will touch only the lines which are standing proud. If the roller is first rolled in ink and then applied to the surface of the plate, ink will stick to the lines but will not touch the other part of the plate. If a sheet of paper is now pressed in contact with the plate, it will receive an ink image of the raised lines. A little thought will determine that the picture on the face of the plate must be a mirror image of the final print.

This method is not used in map reproduction, except for incorporation on a page of newsprint. In such a case the mirror image would need to be drawn on to the surface of the metal plate with grease or some other acid-resistant substance. The plate would then be subjected to an etching process in which nitric acid would attack and remove the surface of the unprotected metal and so leave the mirror-image standing proud.

INTAGLIO

Intaglio processes involve printing from a metal plate, or a stone plate, on which the image portion is incised into the surface of the plate. In this case, ink is applied to the surface so that it enters the incised lines, and is then wiped off the face of the plate. In this way the surface of the plate becomes clean but the image retains the ink and the paper may be printed by simply pressing it against the surface of the plate.

The plate can be prepared either by etching with nitric acid, after the background has been adequately covered with a protective film, or by engraving. The latter was the method whereby maps used to be produced. The engraving was on to stone, or more usually on to copper. The resulting map was an excellent reproduction. However, not only was the engraving skilled and laborious and therefore expensive, but the wiping of the plate after inking was tedious and did not lend itself to mechanization.

LITHOGRAPHY

Lithography means writing on stone. The basic principle is the mutual repellence of grease and water. Originally the idea was to write on a suitable stone using a greasy ink or crayon, then moisten the rest of the surface of the stone and roll with printers' ink which, being greasy, would be repelled by the moist surface and attracted by the greasy drawn lines. This again leaves us with a series of ink lines from which we can print on to a sheet of paper, but this time the lines of the image are neither raised above the remainder of the surface of the plate nor sunk into it. The process is therefore sometimes referred to as planographic.

When printing from stone, a special limestone is used and is carefully prepared to give a plane and slightly textured surface. A very smooth surface is undesirable as it would give no key for the ink, nor would the stone be able to absorb any water.

The image of the map can be transferred to the stone by drawing directly on to the surface, or by using a transfer paper. A transfer paper is a paper with a wax surface on one side. This paper is placed waxed side down on the stone and the map to be reproduced is placed over it. The detail on the map is then traced over using a steel or pencil point and applying sufficient pressure on the point to cause the wax to adhere to the stone below. This gives a wax impression of the map on the stone, but the original document will almost certainly be ruined, and the resulting image will be erect and not reversed as in a mirror image. Ways can be devised for overcoming these difficulties but the method is cumbersome compared with the photographic methods of transferring the image which are considered later.

After the greasy outline has been impressed on to the stone, water is applied to the surface. A greasy ink is now rolled over the surface and will adhere to the greasy image, thus strengthening it and further protecting the stone underneath. The water content on the remaining surface will effectively repel the ink from this part of the stone. The whole surface is now treated with a very dilute solution of nitric acid, washed, and then given a thin coating of gum arabic. The gum arabic combines with the lime on the ungreased part of the surface, and helps to repel the greasy ink. Printing can then be carried out by rolling with ink and applying the paper as before.

Nowadays very similar processes are used, but the base is a metal plate instead of stone; the metals used are zinc and aluminium. In earlier years the more popular of these was zinc and for this reason the method has sometimes been referred to as zincography. The modern trend is towards the use of an anodized aluminium plate.

Stone was found to be too bulky for convenient storage, both before use and for final reference purposes. Metal plates are quite thin laminae, under 2 mm thick; they can therefore be bent for use on the cylindrical rollers of the most modern printing machines. In addition metal will usually work out to be the cheaper medium.

Zincography does not require as thick a plate as letterpress, and so is better for storage and initial cost. Also it is possible to remove the image from the zincographic plate and to use it all over again. The thinner plate is easier to wrap round a cylindrical surface and will give less distortion of the image when it is so wrapped.

Proofing the Plate

Proofing refers essentially to that stage of the reproduction processes during which a few impressions are taken from the plate on paper. These proofs are required for checking the strength of the image, sharpness of line, registration etc. (Registration refers to the accuracy with which the map detail is located relative to the sides of the paper; it is especially important when the map is printed in more than one colour.) The term proving is also often used to include the whole of the final machine printing processes, and it may be entirely by hand as described or it may be done in a press. The simplest presses are manually operated; the plate is placed face upwards, and ink, or water and ink, is applied by a hand-operated nap roller. The paper is then laid on by hand and pressure is applied, either by capstan and vertical screw as in Caxton's original press, or using some other manually-operated mechanical device.

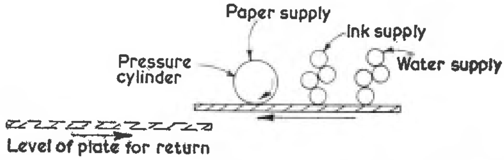

FIG. 8.1. LONGITUDINAL SECTION THROUGH A SIMPLIFIED FLAT-BED MACHINE

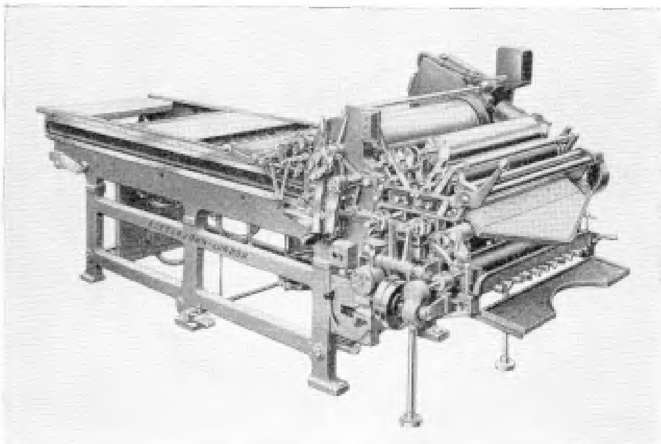

FIG. 8.2. A PROOFING PRESS
(*Sidney R. Littlejohn & Co. Ltd.*)

These methods would nowadays be termed " manual". The modern printing press may be one of two types—

1. the flat-bed,
2. the rotary press.

The flat-bed machines are similar to those last described, but they have been largely mechanized. This type is illustrated in Fig. 8.1. The plate is again laid flat and face upwards, and is made to travel backwards and forwards at different levels under three sets of rollers.

One set of rollers delivers the water, the next the ink and the third, which is a pressure roller, delivers the paper to the surface of the plate. Travelling forwards, the plate moves into contact with each of the rollers in turn, finally passing the printed paper off the end of the machine. In returning to its original position the plate is lowered a fraction of an inch so that it does not touch the rollers. In some machines the plate remains stationary, and the cylinder and roller system traverse the plate.

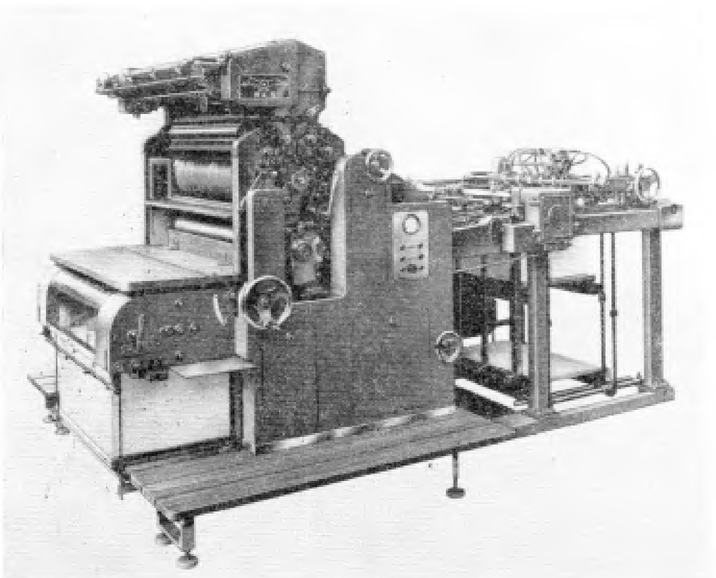

FIG. 8.3. ROTARY OFFSET MACHINE
(*Waite & Saville Ltd.*)

The rotary press has the plate attached face-upwards to the outside surface of a cylinder. Water and ink are fed on to the plate by two systems of rollers as before (see Figs. 8.3 and 8.4). The paper is delivered to another cylinder by a system of suction pads on an endless belt, and is removed by a further system of suction pads. The plate will take longer to fix securely to the cylinder than on to the flat-bed machine, but the speed of printing on the rotary press is much greater. A single run refers to the number of proofs printed (usually termed " the number of pulls ") while the same plate remains fixed in the press. For runs of up to about a thousand, the flat-bed

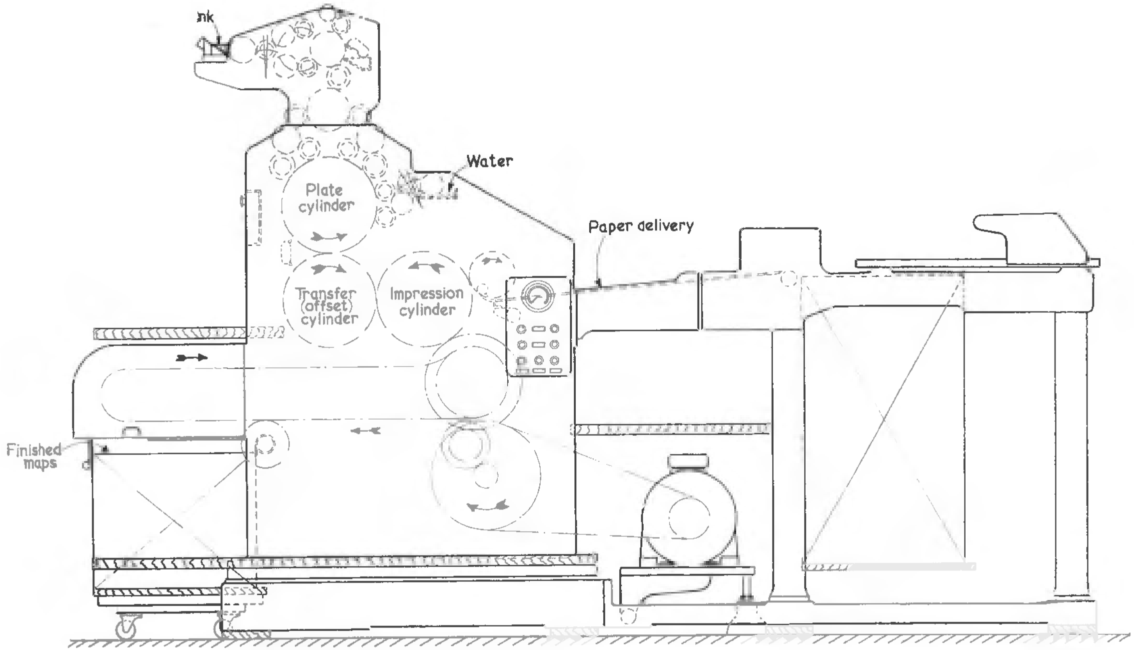

FIG. 8.4. DIAGRAMMATIC SECTION OF A ROTARY OFFSET MACHINE
(*Waite & Saville Ltd.*)

machine will probably be quicker. Longer runs would be more quickly dealt with on the rotary press. The precise dividing line will vary according to the performance of individual models. The proofing press (see Fig. 8.2) is an example of the flat-bed type of press and is especially suitable for taking a few preliminary pulls for inspection as it can be manually operated if desired.

So far we have considered that the paper is printed by direct contact with the plate, when the plate must bear a mirror image. Nowadays it is usual for the machines to contain a third and intermediate cylinder, called an offset cylinder (see Fig. 8.4). This cylinder has a special rubber blanket stretched tightly round it. The function of this blanket is to receive the image from the inked plate, and then pass it on to the paper. When offset printing is used, the image on the plate is erect and the image on the rubber blanket is reversed.

The advantages of offset proofing are that the rubber surface takes a better impression from the plate than the paper does because the rubber fits in to the slight unevennesses of the images. Because of its softness the rubber gives the plate an increased life. The rubber roller also fits into the corrugations of the paper better than the plate does; the main advantage is that a harder and coarser paper may be used. This type of paper gives better stability, i.e. expansion and contraction due to variations in temperature and humidity are reduced. Stability is the most important attribute of a paper, since any change in size means a change in scale of the map. Most litho papers are made from wood-pulp, but rag-litho is a very high quality paper (bank notes are printed on it) and is the type of paper on to which maps are normally printed. Even the coarser qualities of this paper are relatively unstable, and for special purposes (e.g. Cadastral plans) one or two impressions of the plate may be run off on Whatman's paper. Maps which are intended for outdoor use in all weathers (e.g. some military maps) are printed on " wet-strength " paper—a quality usually reserved for carrier bags, packaging, etc.

Where the map is being reproduced in colour, more than one plate is required, and each colour plate is printed on to the paper in turn. In such a case it is essential that changes in temperature and humidity should be kept to a minimum so that the rag-litho paper remains exactly the same size when each successive image is received. If there is any expansion or contraction of the paper between the two successive impressions, then corresponding lines in the two colours will not match up; such result is known as " lack of registration". Some modern machines are designed to print in four colours; the paper passes straight from one colour plate to the next and the ink dries instantaneously.

Correct registration requires that the plate should be accurately located on the cylinder. One way of achieving this is by punching slots in the edges of the plate, and fitting these slots exactly over lugs on the cylinder. Provided that the slots are located in exactly the same position on each plate, the registration should be correct.

PHOTOGRAPHIC COPYING

This can be done either by using a process camera or by contact printing methods.

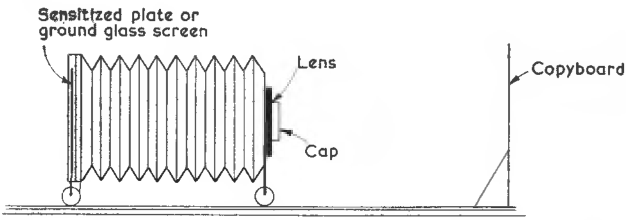

FIG. 8.5. LONGITUDINAL SECTION THROUGH A SIMPLIFIED PROCESS CAMERA (GALLERY TYPE)

The Process Camera

The camera is necessary when it is required to change the scale of the document being copied, and for producing an erect negative. Until recent years the camera was also always required when an opaque original was being copied.

The copy camera is similar to the large studio portrait camera. It consists of the camera body and lens, mounted on rails, and a copyboard fixed vertically at one end of the rails. The simple system is illustrated in Fig. 8.5.

The map, or other document to be copied, is mounted on the copyboard. The cap of the camera is removed and a ground glass screen is placed in the position shown in Fig. 8.5. By moving the lens relative to the ground glass screen, the image of the map is brought into sharp focus on to the screen. The scale of the image is adjusted by moving the whole camera relative to the copyboard and then refocusing. Some cameras are made so that the image automatically remains in focus. The exact scale is achieved by drawing the frame lines of the map to correct scale on the ground glass screen and then making the images of these lines correspond exactly with the drawn representations.

The cap is now replaced, the ground glass screen is withdrawn, and a sensitized plate is inserted in its place. The exposure is made by removing the cap for the predetermined time of exposure. Exposure times will normally be determined by trial and error. A wet collodion plate was often used in this process and was made on the premises (see Chapter 9) but dry-plates produced by various manufacturers are more convenient. Modern cameras are much more intricate, and are provided with a shutter.

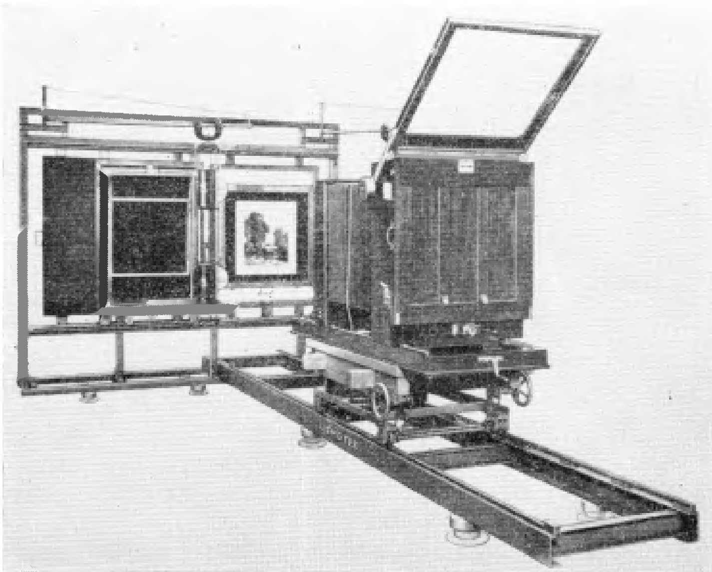

Fig. 8.6. Gallery-type Process Camera
(*Pictorial Machinery Ltd.*)

Cameras must be placed in positions which are subject to very little vibration, and mounted on absorption pads or springs to absorb any remaining vibrations (see Fig. 8.6). Modern developments of the camera include suspension from overhead rails to avoid any interruption to the movement across the floor. Another development is the dark-room camera (see Fig. 8.7) in which the plate holder is stationary within the dark-room wall, while the copyboard becomes moveable. The advantage of this camera over the older gallery type is that the plate can be loaded and unloaded from the darkroom, thus avoiding the use of opaque packing round the plate. A further tendency is toward the use of film cameras.

The camera produces a reversed negative copy, which is an "intermediate" in many processes of reproduction. An erect negative can be reproduced by photographing a reflection of the original map. The reflection may be obtained by using either a

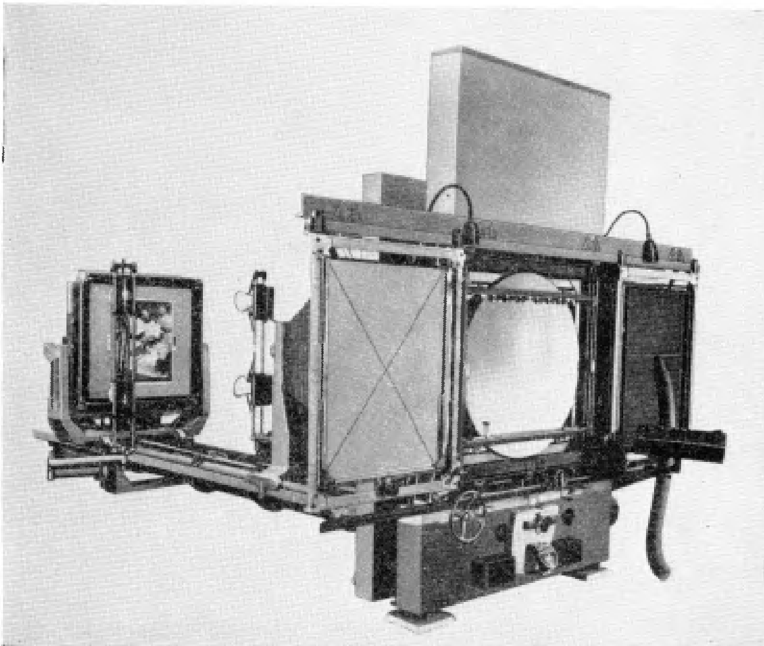

FIG. 8.7. DARK-ROOM TYPE PROCESS CAMERA
(*Pictorial Machinery Ltd.*)

mirror or a prism. Modern copy cameras always incorporate a series of mirrors so that erect negatives are produced from an odd number of reflecting mirrors, and reversed negatives from an even number of reflections. Many smaller modern cameras are constructed with the copyboard laid flat and facing upwards while the plate is kept in a vertical position. In such cameras the reflecting mirrors or prisms effectively turn the image through a right-angle; such instruments are more compact than their forerunners.

The Vacuum Frame

Contact printing is done in a *vacuum frame*. The machine takes many different forms but essentially it comprises a sheet of strong glass and a rubber blanket. The blanket is placed against the glass and all the air between the two surfaces is pumped out, so that the surfaces are held in intimate contact with one another by vacuum. See Figs. 8.8, 8.9 and 8.10.

FIG. 8.8. SMALL VACUUM FRAME SHOWING HAND EXHAUST PUMP
(*Sidney R. Littlejohn & Co. Ltd.*)

Suppose that we want a positive print from an ordinary camera negative and we are using the machine in a " face-up " position, i.e. the glass and blanket are horizontal with the glass uppermost as in Fig. 8.10. The sensitized paper (or metal or plastic sheet) is laid facing upwards on the blanket and the negative is laid on top, emulsion side down. The glass is lowered into position and the air exhausted so that there can be no air-bubbles between the negative and paper as these would distort the image. The frame is now exposed under filament or, more usually, carbon-arc lamps. The print is then developed, washed, fixed, washed again and dried. The fixing prevents any further darkening of the print caused by exposure to light. This is essentially a method of copying from a transparent original or intermediate.

An adaptation of the vacuum frame principle, known as *reflex printing*, enables contact prints to be made from opaque originals.

When only one or two dozen copies of a map or plan are required —such as often happens in an engineering office—reproduction is usually most economically done photographically using a vacuum frame type of machine. Such machines are therefore found as part

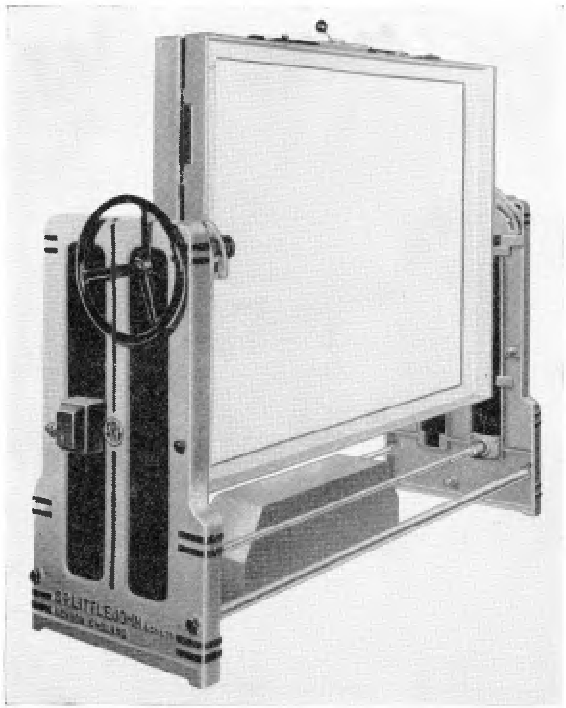

FIG. 8.9. UNIVERSAL VACUUM FRAME (CLOSED AND VERTICAL)
(*Sidney R. Littlejohn & Co. Ltd.*)

of the equipment of a drawing office, where drawings are usually made on transparent materials.

BLUE PRINTS. Perhaps the best known type of contact print is the blue print. This is a print from an original positive transparency on to a paper sensitized with a thin film of ferro-prussiate. Strong light decomposes the ferro-prussiate and the resulting compound turns blue when it is developed in water. The parts of the print under the black detail lines will not be affected by light and will remain white after development. Thus the method gives a white picture on a blue background. It is this print which is called a blue print. If a negative transparency were used the result would be a blue picture on a white background. Until quite recent years the blue print was by far the most popular method of reproducing such documents as architectural or engineering working drawings.

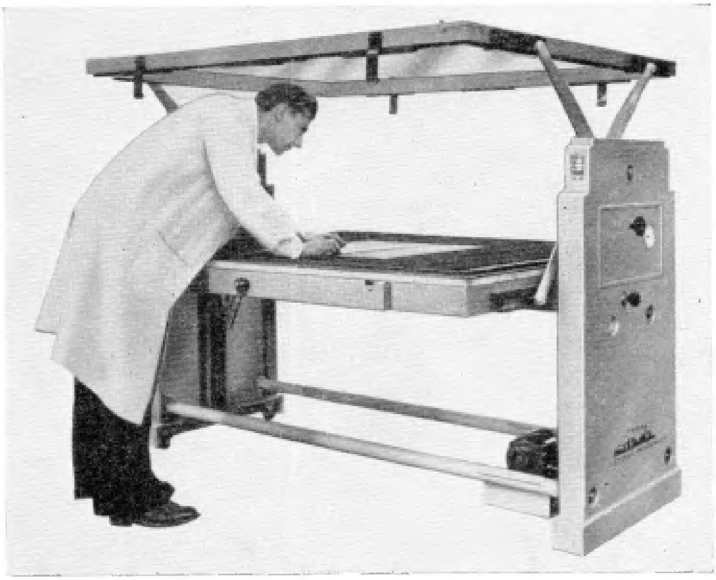

FIG. 8.10. LOADING A VACUUM FRAME
(*Pictorial Machinery Ltd.*)

FERRO-GALLIC. This is sometimes used instead of ferro-prussiate, using a positive transparency as the original. It usually gives a very dark brown picture on a very light brown background. It is often said to be little used, but those who do use it do not agree that it is inferior in any way to the blue print.

DYE-LINE PRINTS. In sunnier climes the product of this process is also known as a sun-print. The sensitizer is a diazo dye, a complex hydrocarbon which decomposes on exposure to light, resulting in a dense black line picture on a bright white background. If it is desired, other colorations can be achieved by a slight change in composition of the sensitizer. The original is again a positive transparency. No dark room is needed, as the whole process can be carried out in daylight, though not in the direct rays of the sun. The exposure is made in a vacuum frame under carbon arcs or strong sunlight. The surface of the paper is yellow before exposure and afterwards a very faint shadow can be seen on the yellow surface. Developing is carried out in a machine in which the print passes between two rollers dampened with an ammonia solution.

Diazotype sensitizers first made their appearance in the 1920s, from which time they have rapidly increased in popularity. Since the 1940s most new drawing office installations have been of this type.

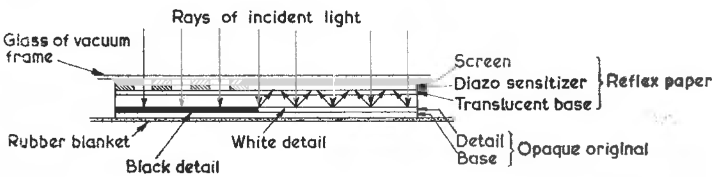

FIG. 8.11. REFLEX PRINTING—SECTION THROUGH VACUUM FRAME DURING EXPOSURE (GREATLY ENLARGED)

REFLEX PRINTING. It is often necessary to make contact prints from opaque originals. This is now possible by using a reflex method of printing similar to that first introduced by Van der Grinven as the Rétocé process. Again a type of vacuum frame is used, but this time if the machine is in the face-up position, the original document is placed face-up on the rubber blanket with the sensitized reflex paper over it (Fig. 8.11). The glass is then placed in position, the air is exhausted, and exposure is made. The top surface of the sensitizer comprises a very thin fine net screen which permits light to enter only through the holes. The base of the reflex paper is translucent; thus at the points at which light passes through the screen it decomposes the dye and then reaches the surface of the "copy." At this stage the layer of dye will be largely unaffected, but will have a network of small decomposed dots. Where the light meets black detail in the original it is absorbed, but it is reflected from the white image areas. This reflected light decomposes the rest of the dye in the areas in contact with the white portions. The screen is now peeled off and the print is developed. The result is a translucent positive in which the image is represented by grey lines. Copies can now be made by the normal dye-line printing methods.

A silver sensitizer could be used in copying documents but normally it would be too fast for convenience. Such sensitizers are used in outdoor photography, and are considered in some detail in Chapter 9.

PHOTO-LITHOGRAPHY

Photo-lithography, as its title infers, is a method of reproducing maps and plans in large numbers by a combination of the lithographic and photographic methods just described. In the following pages it will be assumed that a zinc plate is being used, but the procedure would be much the same if the metal were aluminium.

The process can be considered as comprising four stages—

1. Production of the fair drawing.
2. Preparation of the plate.
3. Transference of the image from the fair drawing to the plate.
4. Proofing.

The last stage has already been considered.

Production of the Fair Drawing

The fair drawing is usually produced photographically from the field sheet or compilation sheet. Suppose that the compilation sheet is not at the reproduction scale, then the usual modern procedure would be to use a process camera to obtain a photographic negative in which the scale was correct. Sometimes it is still considered necessary to make a fair drawing at about twice reproduction scale so that the subsequent reduction will give denser and cleaner linework than the cartographic draughtsman has achieved. This is perhaps the ideal method, but in commercial work it is considered to introduce unnecessary complications.

The base for the fair drawing must be of a very stable material. It will usually be of a dimensionally stable plastic material (such as "Astrafoil"), or of zinc (or aluminium) coated with white enamel. Such materials are known as *topographic bases.*

The surface of the base is then sensitized with ferro-prussiate sensitizer, and exposed in a vacuum frame under the correct scale negative. The developed image will be a positive in non-photographic blue on a white background. A photograph of this image taken through a blue filter would record none of the lines. Such an image is to serve as a guide or templet for the draughtsman, and is known as a *set-off* or sometimes an *off-set.* The cartographic draughtsman must ink in the lines which are to be reproduced, and add names, titling, border, etc. Black ink is used at this stage.

If the map is being reproduced in colour, then a separate fair drawing is required for each colour plate. The same negative, which should be a glass plate to ensure maximum stability, is used to produce separate non-photographic blue images on each of the fair drawing bases. Each plate is clearly marked according to the colour in which it will be printed—black, blue, yellow or red. There are usually two black plates, one for detail and one for names, though on some maps the names are in blue.

The blue plate is inked up with black ink, but only the part requiring to be printed in blue is inked. Similarly the yellow plate is inked up in black, but only that part to be printed in yellow is inked up. So for each of the colours in turn. Thus there will be a separate fair drawing for each printing plate to be produced.

So that the final printing of each colour can be arranged to coincide accurately with the images of the colours previously printed, registration marks are added at this stage. The Ordnance Survey use the four corners of the containing grid or frame for this purpose. Thus the frame must be drawn on the compilation sheet, so aiding the focusing to scale on the ground-glass screen of the process camera. A short length of the lines indicating the frame is then inked in in black on each of the fair drawings, and will therefore be printed in each colour in the proofing process.

Names and symbols are no longer printed manually on to the fair drawing, but are supplied as stick-on transparencies, sold under such trade names as Duraseal and Claritex. Larger map-making firms have their own machine for making these stick-ons by photographic methods.

Where density maps are concerned, or layer-tinting of contours, it is often necessary to print in a large range of tones within one colour—for instance sea under six fathoms might be shown in a pale blue, that between six and twelve fathoms might be shown in a mid-blue, while deeper water might be indicated by a still darker blue. In such a case the shallow area would probably be indicated on the fair drawing by a pattern of very fine black dots, while the middle depths would be shown by slightly larger, but similarly spaced black dots, and the deeper parts by even bigger black dots. Thus with only one printing in a single colour a whole series of tones may be produced. Lines can be used instead of dots, or in conjunction with them, and cross lines may be added. Again the dots or lines will be stick-on ready-made symbols, which besides being quicker to use give a more consistent density of colour and spacing than can be achieved manually. Incidentally the longer a draughtsman takes on a fair drawing the dirtier will it get, so a saving in time also results in a better finished article.

By overprinting one tone of one colour with another tone of a second colour, a further colour may be added. Thus if we print in four tones of each of three colours we can obtain at least sixty different shades in the finished map.

Colour separation processes are an alternative to the above method and are described at the end of the chapter. These methods require one fair drawing in full colour.

Manual tracing is tedious and the linework tends to be uneven, but in recent years a method of producing a good, clean and even-lined transparency by manual tracing has become popular. A sheet of some stable plastic transparency is coated with a thin coloured film. The plastic sheet remains fairly transparent and is placed over the compilation drawing. The draughtsman uses a sapphire pointed instrument to trace the detail on to the transparency. The detail is thus scribed into the coloured film, and can be seen as wholly transparent lines against the coloured background. At this stage we have a negative transparency. To make a positive transparency, special ink is carefully rubbed into the finished surface and the coloured film is then chemically removed leaving the ink detail on the transparency.

Preparation of the Zinc Plate

This includes the processes of (*a*) graining and (*b*) sensitizing the plate.

(*a*) GRAINING. The graining machine consists essentially of a horizontal rectangular tray, having vertical sides about 250 mm high. The dimensions of the tray must be greater than those of the largest plate. The plate is secured to the bottom of the tray and Carborundum powder or fine sand is poured over it and moistened until it forms a paste. Hundreds of glass, porcelain, steel, or wood marbles are introduced, and the tray is oscillated in a horizontal position, causing the marbles to roll about and push the sand particles over the surface of the plate. This action cleans the plate, removing traces of any previous work that may have been on the plate and imparts to the surface myriads of short fine scratches. This unevenness of surface is needed for several purposes including better adhesion of grease and greater water retention properties.

The marbles are of assorted sizes, and the maximum diameter varies according to the processes to be followed, but one firm would normally stick to one size and type—say up to 30 mm diameter glass marbles (steel balls are usually rather smaller). The marbles gradually wear away, but are retained in the machine until they begin to lose shape and bind together; new full-size marbles are added periodically to replace the misshapen ones.

Carborundum powder is often used instead of sand. It is the hardest suitable manufactured material, and is not unduly friable; the grain size can be closely governed, and it tends not to be rubbed into the metal surface.

(*b*) SENSITIZING THE PLATE. The grained plate is washed, dried and put into a special machine called a whirler (Fig. 8.12). This machine is completely enclosed and contains a horizontal table

FIG. 8.12. WHIRLING MACHINE IN OPEN POSITION
(*Pictorial Machinery Ltd.*)

which rotates about a vertical spindle, much like the turntable of a gramophone. When the plate is on the turntable and rotating at the correct speed a measured amount of sensitizing solution is poured on to the plate. The motion spreads this evenly over the plate surface; the speed of revolution is then increased and the coating dried. The film should be as thin as possible consistent with complete coverage.

Transference of Image from Fair Drawing to Plate

There are many methods of making this transference photographically, but all are variations or adaptations of two main groups of processes—

(*a*) The *helio process* now more popularly known as the *albumen process.*

(*b*) The *Vandyke process* with its modern development the *gum-reversal process*.

(*a*) THE ALBUMEN PROCESS. In this process the plate is sensitized with bichromated egg albumen, on to which the image is transferred by contact printing from a negative copy of the fair drawing. In this case, then, the image areas themselves become light-hardened. A fairly hard developing ink is applied to the surface using a smooth nap roller, which is rolled carefully in all directions on the plate until a thin even hard film of ink is obtained.

The plate is then immersed in water and soaked for a minute or two. After this the image may be developed in running water by gently rubbing the surface with cotton wool which must be kept free from ink by continuous washing.

The unexposed soluble albumen is thus removed, leaving the image clean on the plate which now consists of a clear zinc background bearing a positive image. This image is composed of a strong film of greasy ink incorporated in, and superimposed on, the well-hardened albumen image. French chalk is dusted on and the background is " etched " with a dilute nitric acid. This is not of course a true etch, but is only a process evolved to increase the plate's attraction to water.

After washing again, the plate is ready for proving. For storage or during respites from proofing, the plate must be thoroughly cleaned with asphaltum solution, washed and dried. It is protected with a coat of gum arabic which must be removed before the plate is proved again.

The thin layer of albumen separating the ink image from the plate eventually breaks down on the run, which can therefore never exceed thirty thousand pulls.

(*b*) THE GUM-REVERSAL PROCESS. The first step in this method is to prepare a positive transparency, which needs to be reversed if proofing is to be on an offset machine. The grained plate is sensitized with bichromated gum arabic (the resin exuded by the acacia tree), and is exposed under the fair drawing in a vacuum frame. The fair drawing is placed face down on the sensitized plate, so that the image is in direct contact with the emulsion. The image therefore suffers inversion at this stage.

The effect of light on the bichromate is to harden it. Thus that part of the plate unprotected by the lines of the fair drawing will become light-hardened during exposure.

The plate is now dipped in an aniline dye—violet, scarlet and vermilion tints are the most popular. The effect is to give a vivid colouring to the face of the plate. Development of the image is carried out in clean water. The unhardened part of the gum-arabic film is dissolved out with a lactic acid solution or washed away with a soft cloth, leaving the image visible as white metallic lines in a highly coloured background. The latter consists of the light-hardened relatively insoluble chromate which is now used as a stencil.

When dry this stencil can be touched up and strengthened using a solution of gum arabic.

A slight true etch (sometimes misleadingly called a deep etch) is now given to the line areas by applying a solution of iron perchloride and hydrochloric acid. The stencil protects the non-image areas, and the etch forms a key into which a rosin lacquer is rubbed. Lithographic ink is then rolled well in and the stencil is removed by light scrubbing in warm water.

After the removal of the stencil the plate is washed and treated briefly with a dilute solution of nitric acid to increase the water retentivity of the non-image part of the plate. This step is sometimes referred to as etching, though it does not result in a true etch.

Note that the image is still covered with a film of lithographic ink.

After washing, the plate is ready for proofing. When not in use the plate should be cleaned with asphaltum solution, dried and given a protective coat of gum arabic. This should be done even for pauses during a run.

The process is called reversal because it is the reverse of the albumen process in that in the latter the development of the image is done by washing away the non-image parts of the emulsion film, and the image is transferred from a negative fair drawing.

The original Vandyke process is essentially the same as the modern reversal process but the sensitizer is bichromated fish glue, no deep etch is given to the line areas, and the stencil is removed with an acid solution.

The original Vandyke process was the first to be used for commercial photo-lithography, but the albumen process replaced it and became the standard method for many years. Now the gum-reversal process has replaced the albumen process, mainly because it gives a greater strength of line and therefore a more durable image. However, for very long runs it has been found that, although the image remains intact, the graining of the plate itself begins to break down, causing loss of water retentivity. Thus for runs approaching a hundred thousand an anodized aluminium plate is necessary. In large commercial firms most work is now done on these plates; the process is very similar to the reversal process but the aluminium plate is grained and anodized by the manufacturers.

Half-tone Photography

So far we have spoken only of continuous-tone or line diagrams, but it might be necessary to reproduce a photograph, such as an air-photograph, by lithographic methods. This would be very likely to happen if it were required to reproduce a mosaic in large numbers. Such a document is composed of many tones of grey, with black and white as the extreme limits. This problem is dealt with by introducing a cross-line screen in the camera when the negative is being produced. The effect of this is to split the image up into a regular pattern of dots; the size of the dots varies with the depth of tone to be recorded.

A plate produced by this method is known as a half-tone plate or block. The cross-line screen consists of two plates of glass, each of which has been ruled on one face with a series of fine parallel straight lines such that the black lines and the clear spacing between are of equal thickness. The two glass plates are then cemented together so that the lined surfaces are in contact and one set of lines is perpendicular to the other. There are usually between 4 and 5 lines per mm depending on the type of work being done.

The screen is placed in the camera just in front of the focal plane. In the negative, light tones of the original will be represented by white dots on a black background, and dark tones by black dots on a white background, the background dominating; the effect will be reversed on the print. If a newspaper photograph is examined closely the texture described above can be observed; the pattern is much more obvious when looking in some directions than in others.

Colour Separation Processes

These can be used to produce separate colour plates from one fair drawing in full colour, i.e. from a map containing large *areas* of colour. Most modern maps are composed mainly of lines and individual symbols, and can therefore be readily transferred to a series of fair drawings by the normal methods described earlier.

Colour separation is usually achieved by a subtractive process. The subtractive primaries are primrose, blue-green, and magenta, and it is useful to think of them as minus-blue, minus-red, and minus-green respectively. The effect of applying e.g. primrose ink to white paper is to prevent the paper from reflecting blue light. Areas printed in primrose and magenta will therefore appear red, and areas printed in all three primaries will appear black.

A separate negative is first obtained for each colour plate by photographing the single fair drawing through a particular colour filter or cut-out. These filters must be of as fine a quality as the lens in order that register is not disturbed. Tri-colour work is normal and the filters used are blue, red and green. Each filter is used separately and passes all light which it is desired *not* to print so that the clearer portions of the film are a record of the " heldback " colour. A blue filter is needed for the primrose printing plate, a green filter for the magenta plate and a red filter for the blue-green plate (see Fig. 8.13). A light green-yellow filter is used for the black or grey plate. Tone values for each colour are produced by the use of a cross-line screen.

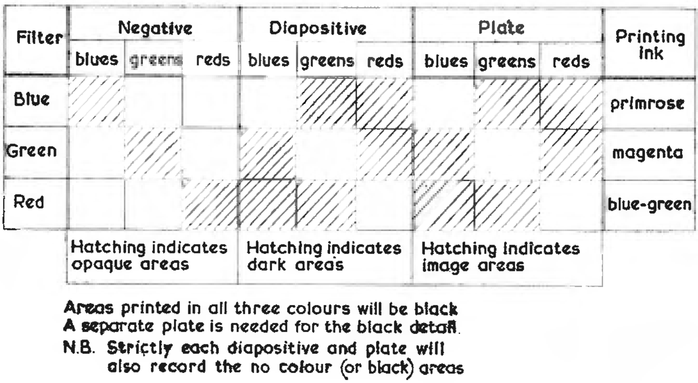

FIG. 8.13. COLOUR SEPARATION BY A SUBTRACTIVE PROCESS

The cross-line screen and the filter may be used in the camera at the same time to produce the negative in one operation, but some firms prefer to obtain a normal photographic colour-separate negative first, and use the cross-line screen in rephotographing a contact print of this negative.

A half-tone positive transparency is produced by contact printing, and this is used to produce a printing plate by the gum-reversal process.

Revision of Plate

A lithographic printing plate may be revised by removing obsolete detail with a scribing tool and putting in new detail by direct drawing using chalk or sawdust as offset guide lines. Such revision is easier to carry out on the erect-image plates used in offset printing methods.

The main difficulty is in making areas which were previously line areas attractive to water, and in large commercial concerns it is unusual to carry out revision on the plate. It is normally much easier to revise the fair drawing and make an entirely new plate. This is especially true when anodized aluminium plates are used.

FURTHER READING

Map reproduction is very poorly documented but there are books dealing with PHOTOLITHOGRAPHY.

References to " Photo-mechanical Processes " should not be overlooked, since the term means much the same as " Photo-lithography."

Ilford Ltd., have produced a booklet entitled *Document Copying with Ilford Materials* which is a useful reference for purely PHOTOGRAPHIC COPYING methods.

See Trorey, Appendix I, for a drill for fair drawing and a helpful system of checking.

(See Bibliography (page 346) for the full titles.)