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PHOTO-MECHANICAL PROCESSES OF MAP PRODUCTION

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Zinc Printing.

THE object of every photo-mechanical process is to produce a zinc printing plate, and before dealing with the processes it is advisable to say a few words about printing from zinc.

Printing from zinc is rendered possible by two factors: the affinity of zinc for grease, and the mutual repulsion of grease and water. If a line is drawn with greasy ink on a dry zinc plate, the zinc holds so strongly to the grease that the line cannot be erased by any ordinary method; nothing short of caustic potash will remove it. On the other hand, if the surface of a zinc plate is wetted, greasy ink will not adhere to it at all, because the water on the surface repels the grease.

The preparation of a zinc printing plate consists of producing in greasy ink on the surface of the plate—either by drawing, or transfer, or by some mechanical process—a facsimile of the map to be printed. The printing from the plate involves three separate processes for each impression. First, the plate is damped; the greasy lines on the plate repel the moisture and remain dry; the remainder of the plate is wet. Second, an inky roller is passed over the wet plate; the ink from the roller adheres to the dry greasy lines on the plate, but will not adhere to the damp surface of the plate. Third, a sheet of paper is pressed against the face of the plate, and an impression printed on the paper.

In order that the plate may remain damp throughout the printing process the surface is grained. This is done by scouring it with sand. The minute scratches on the plate exert a capillary attraction for the water, and cause the plate to behave as if it was slightly spongy.

Vandyke Process.

The simplest mechanical method for producing a zinc printing plate is by the Vandyke process, in which a grained zinc plate is coated with a film sensitive to light. The sensitive film is composed of fish glue and ammonium bichromate. This film is soluble in water until it is exposed to light. After exposure it becomes insoluble.

The map to be reproduced is laid face downwards on the sensitized zinc plate. The light then penetrates right through the paper on which the map is drawn, except where its passage is prevented by the black lines of the map. The whole of the glue film is thereby rendered insoluble, except those portions which have been masked by the black lines. The paper may be either white drawing paper or tracing paper.

After exposure, the plate is washed with water, and all the soluble glue is dissolved away, exposing the zinc surface. The insoluble glue is

not affected by the water. At this stage the map makes its first appearance on the plate as lines of metallic zinc, showing through cuts in the insoluble film. The plate is then covered with greasy ink. The ink adheres strongly to the metallic zinc where it is exposed.

The next step is to get rid of the insoluble film of glue by washing the plate with a very dilute solution of sulphuric acid. The acid loosens and removes the glue film, but does not attack the greasy ink. Consequently, the plate emerges from the acid bath with a clean zinc surface upon which the detail of the map appears in greasy ink.

The plate is then ready to go to the printer. It will be realized that the Vandyke process can only be used where it is intended to produce copies of a map on exactly the same scale as the original drawing.

In making the Vandyke plate, the drawing is pressed very tightly against the zinc plate in order to prevent the light creeping between the drawing and the plate. But the plate and drawing are separated by the thickness of the sensitized film, and there is always a slight diffusion of light sideways through the film. This tends to reduce the thickness of the lines on the plate, as the light creeps in on them from both sides. As a result, very fine hair lines in a drawing often fail to appear at all on the Vandyke plate. They are nearly always weak and broken.

Helio Process.

When it is desired to reproduce a map on a scale that is not the same as the original drawing, a photographic camera must be used. This process is known as heliozincography, or, more shortly, as the helio process.

The first essential is a suitable lens. The best lens that we have at Southampton is 8 inches in diameter, made by Zeiss. It has a focal length of 70 inches, and is free from any appreciable distortion. Its present value is about £3000.

In photographing maps only wet plates are used. The wet plate is far superior to the dry plate for this purpose, because the image on a wet plate lies entirely on the surface of the film. On a dry plate the image is dispersed through the whole thickness of the film. As a result of this, dry-plate negatives produce a print that is soft and woolly, compared with the hard clear outlines produced from wet-plate negatives.

The map to be photographed is pinned up on a large copy board, and focussed on a ground-glass screen, on which are marked the corners of the map which is to be printed. The copy board and screen are moved backwards and forwards until the image of the drawing is in good focus, and fits exactly into the four corners marked on the ground glass. The wet plate is then substituted for the ground glass, and the exposure is made. The length of exposure is limited by the drying of the plate. If the plate becomes dry it is spoilt. The maximum exposure that can be given is about thirty minutes, and this only if the atmosphere is very moist. After exposure the plate is at once developed and fixed. The

resulting negative consists of a glass plate coated with a black, opaque, collodion film, in which the detail of the map appears as clear transparent lines.

The next step is to prepare a zinc printing plate from the glass negative. This is done by sensitizing a grained zinc plate with a film of bichromated fish glue and albumen, and exposing it under the negative. Albumen is used to harden the film. The light passing through the clear lines on the negative renders the fish glue and albumen insoluble. The rest of the film being protected by the opaque film remains soluble. There is a small creep of light in the sensitive film, which tends to widen the lines of the map.

After exposure, the zinc plate is inked up with greasy ink. It is then washed with water and gently rubbed with cotton-wool. All the soluble portion of the film is thus washed away. The insoluble portion remains, and the map therefore appears in the form of greasy lines on a clean zinc plate. The plate is then ready for the printer.

Drawing for Reproduction.

The foregoing is a very short and condensed description of the Vandyke and helio processes. It is necessary now to deal with the more important of the difficulties that arise. They may be classed under two headings : (1) those due to unsuitable drawing paper ; (2) those due to unsuitable drawing.

Paper is very sensitive to changes of humidity in the atmosphere. If the air becomes damp the paper expands ; if it becomes dry the paper contracts. Different makes of paper expand and contract in different ways. Hand-made papers expand to approximately the same extent in every direction, so that a map drawn on hand-made paper is generally the correct shape, no matter how much it has expanded or contracted. Machine-made papers expand in one direction only, so that a map drawn on machine-made paper is never the right shape, if expansion or contraction has taken place.

If the drawing of a map has expanded or contracted, the obvious way to bring it back to its original size is by drying or damping it. This is sometimes feasible, but not always. A piece of paper which has remained damp for a considerable time takes a permanent set, and will not dry back to its original size.

If the map is to be reproduced by the Vandyke process, all that can be done is to bring it back to its original size as far as possible by drying or damping. The residual error cannot be eliminated. If the map is to be reproduced by the helio process, and the drawing has expanded or contracted equally in all directions—as is usually the case with hand-made paper—the error can be rectified by the camera. But if the drawing is on machine-made paper, and has expanded or contracted, there is distortion, which cannot be eliminated.

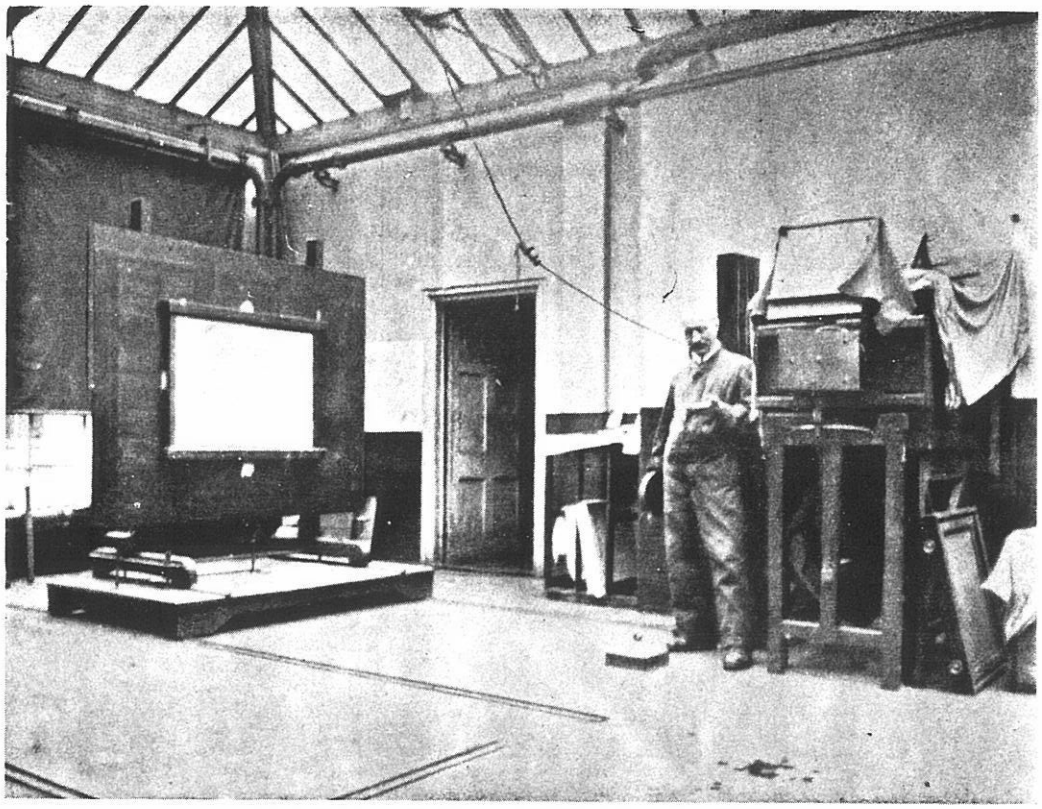
From this it is clear that hand-made paper is to be preferred to machine-made. On the Ordnance Survey there is a rule that only hand-made paper shall be used for original drawings. Drawings on tracing paper, though suitable for reproduction by the Vandyke process, give a good deal of trouble when photographed for the helio process. This is due to the tracing paper not being pure white, and in consequence the film on the resulting negative is not a dense black. If the film is examined with a strong magnifying glass, it will be found riddled with minute pinholes, which are the photographic images of the tiny coloured particles of oil or resin which has been used to render the paper transparent. When the helio plate is being made, these pinholes in the negative encourage the light to creep in the sensitive film on the zinc plate. The final result is coarse and woolly lines on the zinc plate, and on the impressions printed from it.

The difficulties that arise from unsuitable drawing are of two kinds. The first is due to the use of ink which is not sufficiently black and opaque. If the ink is at all grey, the fine lines cannot be reproduced by either the Vandyke or helio process. It has been found on the Ordnance Survey that Indian ink can be rendered very opaque by mixing with it a little cadmium-orange. This has greatly reduced the trouble caused by grey lines. The second cause of trouble arises from lines being drawn too close to one another. When this is the case, the lines nearly always run together after a few impressions have been pulled from the zinc plate. A good rough rule is that lines should never be less than their own width apart. This rule of course applies to letters as well as lines. To avoid the closing up of letters a fairly light and very open face of type should be used.

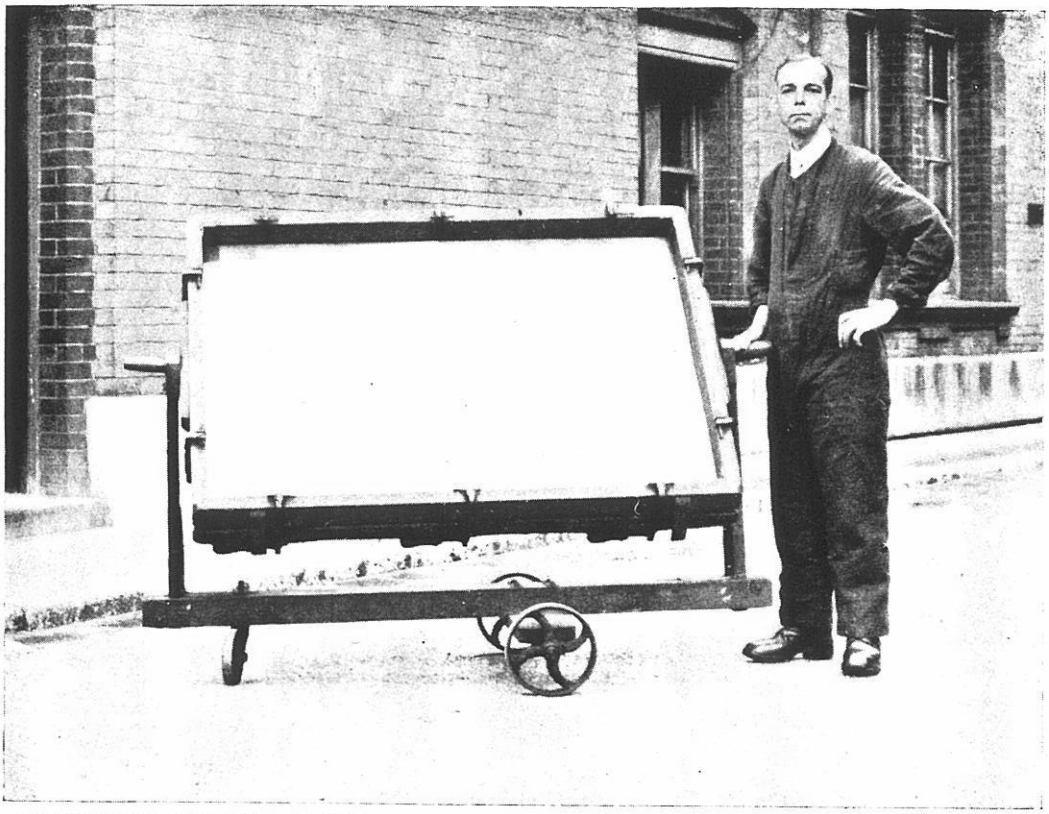
Reference has already been made to the tendency of hair lines to disappear in the course of reproduction, especially in the Vandyke process. To overcome this difficulty the Ordnance Survey has recently adopted a new style of type to be used on the 25-inch map, which is reproduced by the Vandyke process. This type is of the sans serif family, and contains no hair lines. It is hoped that the use of this type will greatly reduce the amount of touching up required on the zinc plates.

Drawing for Reduction.

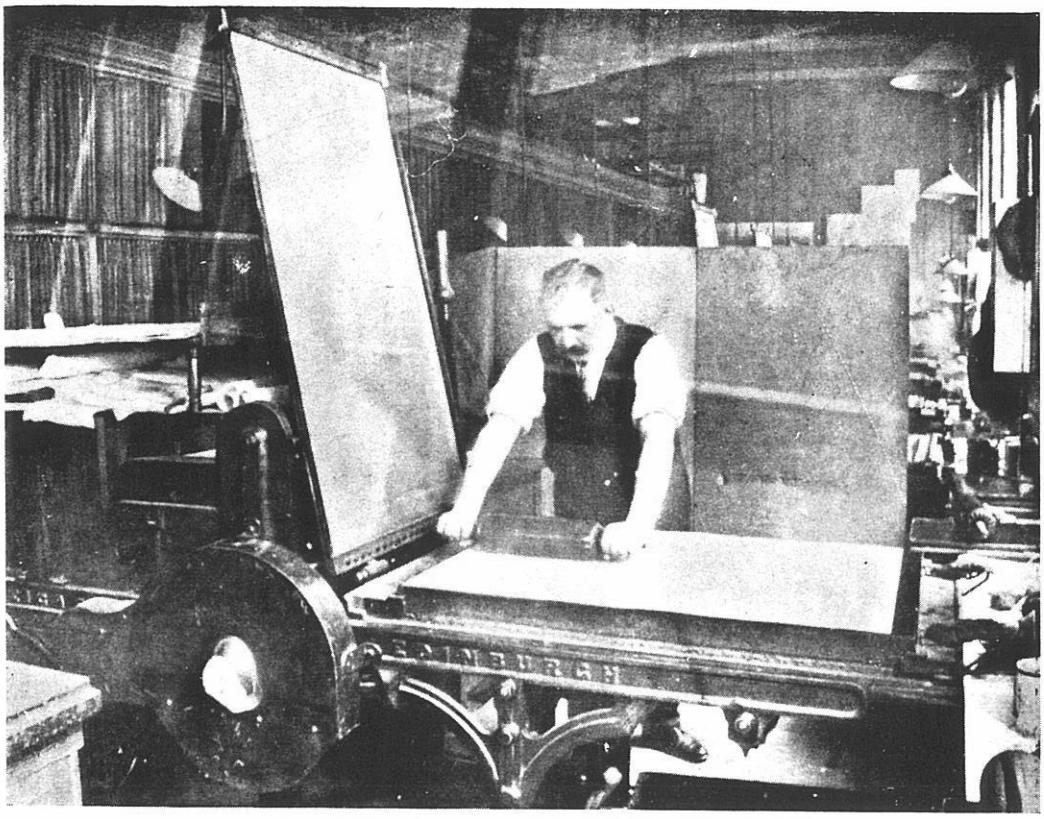
When drawing for reproduction by the helio process, the final result can be greatly improved if the drawings are made on a larger scale than is required for the finished map. On the Ordnance Survey maps are generally drawn to twice the scale required, and the necessary reduction is made by the use of the camera. The advantage gained by reduction is due to the fact that the intensity of illumination of the photographic plate increases with the amount of reduction. The more intense the illumination the denser the film on the negative, and the sharper the lines. For a reduction of 2 to 1 the illumination is 1·6 times as intense



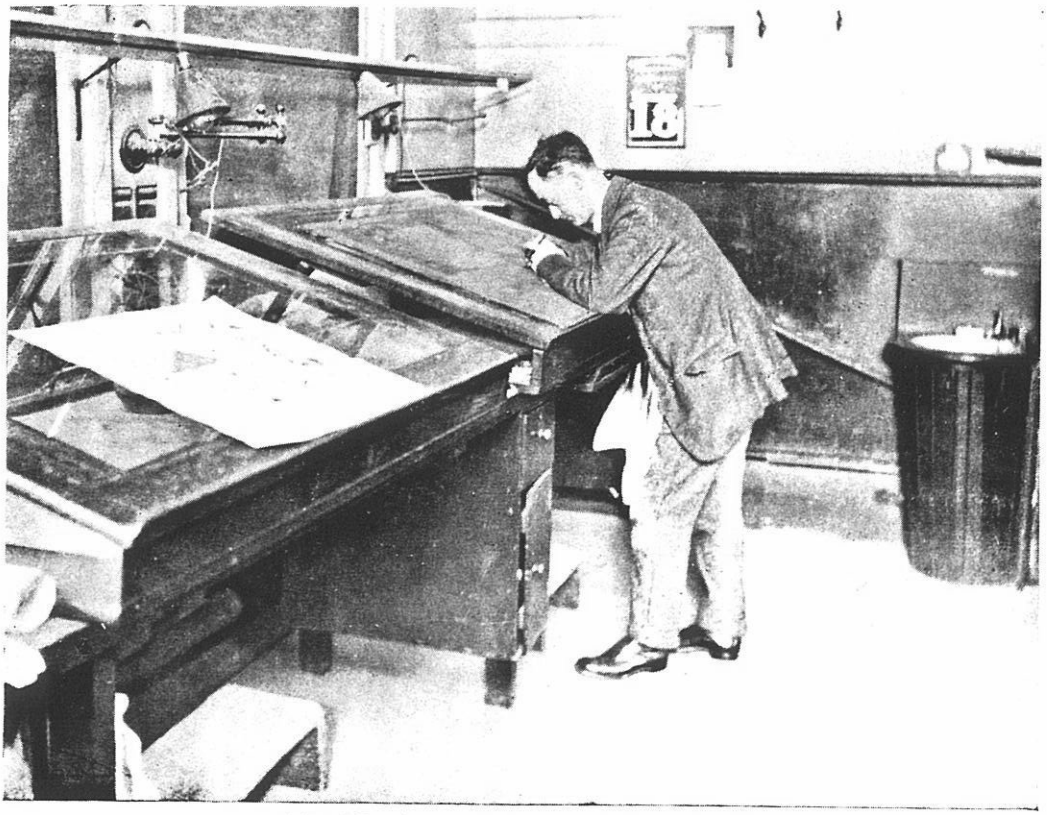
MAKING THE NEGATIVE FOR A HELIO



PRINTING FRAME WITH VACUUM BACK FOR MAKING VANDYKE AND HELIO PLATES



HAND-PROVING A ZINC PRINTING-PLATE



CORRECTING A GLASS NEGATIVE

as the illumination when photographing to the same scale. To get a constant density of film the length of exposure must vary inversely as the illumination, so a negative made to the same scale must be exposed 1·6 times as long as one reduced to half scale. The trouble with these long exposures is that the fine lines on the negative gradually close up. In fact, if the exposure is very long the fine lines in the centre of the negative, where the illumination is strongest, will be entirely lost before the film at the corners has become sufficiently dense.

The conditions required to produce the best results in the helio process are: (1) very black lines drawn on very white paper; (2) a reduction of at least 2 to 1; (3) as brilliant a light as possible (good daylight is much better than any artificial light).

Photo Etching.

In addition to the Vandyke and Helio processes there is a third photo-mechanical process called Photo etching. In this process a negative is made of the map in just the same way as in the helio process. From the negative a positive is made, on which the lines of the map appear in black on a transparent ground. A thin copper plate is then sensitized with a film of bichromated fish glue, and exposed under the positive. After washing, the lines of the map appear as metallic copper in a film of insoluble fish glue.

The next process is to bake the plate in an oven. This turns the fish glue into a sort of enamel. After baking the plate is etched with per-chloride of iron, which eats away the metallic copper where it is exposed, but does not touch it where it is protected by the enamel. The result is a copper printing plate on which the lines of the map are cut in. The enamel is removed with caustic potash.

In practice, the etching process cannot be carried very far as the lines tend to widen as well as deepen. Consequently the etching has to be stopped before the lines are deep enough to hold sufficient ink for printing. The deepening of the lines has to be done by hand. It is a long job, and must be carried out by a skilled engraver. For this reason the photo-etching process, though it is classed as a mechanical process, has very little right to the title. When the copper plate is ready, a transfer is printed from it, and laid down on a zinc plate, which is used for printing the copies of the map.

The photo-etching process was used for a time on the Ordnance Survey, but has been abandoned. The objections to it are: (1) it involves the use of transfers. This introduces distortion because the transfer paper, when laid down on the zinc, is never the exact size and shape of the map on the copper plate. (2) It is a long and expensive process, as it involves a large amount of work by a skilled engraver.

Revision.

In selecting a process for map reproduction, attention must always be paid to the question of revision. Maps of countries in which developments are taking place very soon become out of date, and it is then necessary to revise them and to publish new editions. For the purpose of revision, the helio process offers very great advantages over any other, since revision can be carried out on the existing negative. Any detail which is obsolete is simply painted over with lamp black on the negative. New detail is cut on the negative film with a fine steel needle. When the corrections are complete on the negative, a new zinc printing plate is made from it in the usual way. This method of revising on the negatives has been adopted for all small-scale maps of the Ordnance Survey.

The helio process has a further advantage in that the negative is the most permanent and accurate record of a map. It does not deteriorate when kept in store, and it is always true to shape and scale, and as a record it is therefore far superior to the original manuscript drawing, which often becomes warped and discoloured with age. When a negative is in existence a printing plate can be made from it in less than an hour. It is a great comfort to a zinc printer to know that he can get a new printing plate whenever he wants one, and at a short notice

Colour Plates.

For coloured maps a separate printing plate must be prepared for each colour. The difficulty is to ensure accurate registration between the various plates. If the registration is not accurate the blue rivers will not run under the black bridges, and the red contours will wander into the blue rivers, and many other atrocities will occur.

The best way to ensure registration is to make a complete drawing of the map, including rivers and contours, in black. This drawing is then photographed three times without touching either copyboard or camera. The three resulting negatives are then identical. On the first negative the water and contours are duffed out. From this negative the black detail plate is prepared. On the second negative everything is duffed out except the water. From this negative the blue water plate is prepared. On the third negative everything is duffed out except the contours. From this negative the red contour plate is prepared. These three printing plates will be in perfect register with each other.

In practice it is found that the duffing out of so much detail from three negatives is too expensive. We therefore adopt the second best method. We draw the black outline on one sheet of paper, and the water and contours on a second sheet. The black detail is photographed first, and then without moving the copyboard or camera we pin up the contour and water drawing over the detail drawing, taking

care that the corners of the two drawings correspond exactly. Two negatives are made from the contour and water drawing. From one the contours are duffed out, and from the other the water. These two negatives give us our water and contour plates respectively.

Offset Printing.

In an offset printing machine a rubber-coated cylinder is interposed between the zinc plate and the paper. An impression from the zinc plate is printed on the rubber cylinder, and then transferred from the rubber cylinder to the paper.

This method has many advantages. It makes the zinc plates last much longer, because the rubber wears the surface of the plate much less than the paper. It gives a fine and more uniformly inked impression. The output per hour of the rotary offset machine is about double that of a flat-bed machine.

It should be noted that a zinc plate prepared for a flat-bed machine must be a negative plate. That is, the writing on it must read from right to left, the east margin must lie to the left, and the west to the right, etc. But for the offset machine the zinc plate must be a positive plate, so as to give a negative impression on the rubber, and a positive impression on the paper.

Now the Vandyke process can only give us negative plates, so we must always print these plates in a flat-bed machine, unless we are prepared to go to the expense of reversing the plates in a reversing press. This is hardly ever justified.

In the helio process, if we wish to produce a negative plate for the flat-bed machine, we must photograph the drawing with a prism fixed in front of the lens, so that the photographic negative is actually a positive image of the map. This will give us a negative image on the zinc printing plate. For offset printing we remove the prism from the front of the lens, and the photographic negative is then a real negative, and the zinc plate made from it is consequently a positive image of the map.

Before the paper the PRESIDENT said : The paper this afternoon is on the subject of " Photo-Mechanical Processes of Map Reproduction," and it will be given by Colonel Craster, who is eminently qualified to discourse to us upon the matter. He has for some years, I know, been the printing officer at the Ordnance Survey, and for a good many more years has taken a keen interest in this particular branch of science. He will explain to us the processes which are employed for the reproduction of maps, and we shall listen with much interest to what he has to tell us.

Lieut.-Col. Craster then read the paper printed above, and a discussion followed.

Col. E. M. JACK (Director-General, Ordnance Survey) : I should like to pay a tribute to the work that Col. Craster has done in charge of the printing

department at Southampton. He has approached the subject from a more scientific point of view than many who have been in charge of that department, with excellent results.

There are just two points I should like to mention. You saw specimens of a map reproduced by the Vandyke and by the helio process, from which it might be thought that the latter gives coarser results. This it does only when the reproduction is on the same scale. The helio process is intended for reproduction of a reduced scale, and that is what should always be done. Our usual practice is to reduce the scale by one-half, and thus to get finer results.

The other point is with regard to the adoption of photo-mechanical processes. The Ordnance Survey, as you probably all know, has been well known for many years on account of its engraved maps, most beautiful of their kind. But we have now definitely abandoned engraving in favour of photo-mechanical processes. This change was practically forced upon us by modern requirements, since in our opinion engraving is not suitable as a basis for coloured maps, bearing in mind the kind of map that it is wished to produce. It may be suitable for certain kinds, but when you take into account, as every printer has to, the particular kind of map you are printing, the particular kind of register that you want, the number of colours used, and so on, it is not in certain cases, particularly in Ordnance Survey maps, so suitable as a basis for coloured maps as the helio process. Apart from that, the helio process has certain decided advantages, which Col. Craster has pointed out.

Fears have been expressed by those who know the beautiful old engraved maps of the Ordnance Survey that the quality of Ordnance Survey maps will deteriorate in consequence of the decision to abandon engraved maps. The answer to that will be found, I think, in the two maps displayed in this room, which are recent productions. The originals for those maps were drawn on twice the scale ; they have been reproduced by the helio process and engraving has not come into them at all. I hope you will agree with me, and I believe you will, that there has been no falling off in the quality of our reproduction ; that those are beautiful productions as maps ; and that they keep up the standard of the Ordnance Survey, of which we are all, I hope, proud as a national asset.

Col. H. S. L. WINTERBOTHAM : There are one or two points which seemed to me of particular interest in this paper. First of all, Col. Craster, in comparing the Vandyke and the helio processes, showed that, in both, one of the principal difficulties is the creeping or diffusion sideways of the light between the sensitized zinc plate and the glass or paper. I do not think that the diagram which he showed is particularly expressive of what happens. Paper, of course, fits more or less closely upon the sensitized film, and because it does so I think there is much less diffusion of light in the Vandyke process than in the helio process. In the latter the glass itself comes down upon the zinc plate, and thus there are two hard surfaces between which it is impossible to get a perfect fit. Again, in the diagram you saw two parallel rays of light, but you do not get this parallelism in practice. It is only, I think, in the Survey of India that a parallel beam of light is employed.

The principal reason for the diffusion of light is that it is coming at all angles and directions, and there is naturally diffusion. The question as to whether you ought, therefore, to confine yourself to a parallel ray of light wants, I think, a little consideration. Again, it is quite plain from the diagram that the diffusion of light is a function of the depth of the sensitized film. I am not at all satisfied that fish-glue is a necessary ingredient of this film, but perhaps Mr. Crawford may speak a word on that point later with more technical knowledge than I possess.

After discussing the Vandyke and the helio processes Col. Craster referred to the necessity for certain measures in preparing the fair drawing. He pointed out that there should be a reduction of about 2 to 1 to get a perfect helio result. He showed us that this reduction was made necessary by troubles which are partly photographic and partly due to the diffusion of light. That is to say, the reasons for the coarsening of lines lie partly in the camera itself and partly in passing the work from the negative to the zinc. How much of the trouble shall we assess to the camera, and how much to the helio? If we say a quarter to the camera and three-quarters to the helio, I think we shall be more or less right. The helio process is very admirable, and indeed one must use it nowadays, but it will not be perfect until by research we arrive at the stage at which we can eliminate the percentage of coarsening due directly to the process and are able therefore to confine reduction to $1\frac{1}{4}$ to 1. It has not been mentioned, with regard to drawing, that the cost and time of drawing are not proportional to the area of ground in question so much as to the area of paper. Supposing that he is drawing at 2 inches to the mile, a draughtsman will take nearly as long completing a square inch as when he is drawing at 1 inch to the mile. So that the costs of drawing are nearly doubled, and obviously the process cannot be considered absolutely satisfactory until these troubles have been eliminated, and one may draw for a very small reduction.

With regard to photo-etching, the worst trouble, as Col. Craster rightly pointed out, lies in the fact of the personal work which has to be done by an engraver after the photographic process is finished, but his intervention is only necessary because of the style of ink with which we print. The etching itself is shallow for the reasons Col. Craster has given, and then the engraver has to cut deep in order to give a key to that sort of ink with which we are accustomed to print. Photogravure does not use the same style of ink, and we know that there are machines on the market in which the " doctor " or knife used for photogravure is employed on a flat bed almost as successfully as it is more normally used upon curved or cylindrical copper plates. Photogravure ink is very liquid and very thin. It is made with a spirit foundation—I think ordinary naphtha—and it will not " key " in large areas. In the photogravure process it is held in position by a sort of screen which gives the so-called " cell walls," or little compartments. To make photo-etching independent of the engraver we have, then, only to evolve some sort of method of getting these cell walls on to the plate. Perhaps Mr. Crawford might know something about the possibilities of doing so.

Finally, although we possess a very good process in helio-zincography, we have got to keep our eyes open to the possibilities of photogravure. We have been told this evening of the speed with which a rotary off-set machine can print. But in the photogravure process you can multiply that speed by ten, if you like. The present and the obvious troubles of photogravure for map printing, of course, are those of register. The paper is hustled on and off the plate at a prodigious speed, and in the first instance the work is put down on the copper through a paper medium which is subject to considerable distortion. However, I have very little doubt that a method will soon be found which will eliminate these troubles.

The PRESIDENT: Mr. Crawford, Superintendent of Map Printing at the War Office, is here, and I think it would be interesting if he would give us his experience of photo etching and also his opinion as to the value of photogravure for the purposes of map reproduction.

Mr. JAMES CRAWFORD (Superintendent, Map Printing Department, War

Office) : I approach these processes more from the practical than the theoretical point of view. The lecturer has given us a lucid explanation of them, and to the lay mind it probably appears quite simple and easy. As he says, if it were so our staff would be considerably reduced. But I can assure you that is not so. There are many pitfalls that are not referred to in text-books even. It all sounds very simple, but when one comes to practise the process then one is up against all the difficulties. I will touch on only a few. One of the chief points I have discovered in practice is that in coating zinc plates there are many factors to be considered ; so many operations in the process depend the one upon the other. If you have a coarse-grained plate—and grain is indispensable—the solution that you coat it with must be of such a consistency that it will give a uniform film over the whole plate ; that is to say, fill up all the grain in the plate. If the film is too thin in albumen, then the points of the grain protrude through the film, with the result that when the plate is inked up after exposure all those minute points of the grain are covered with ink, which it is practically impossible to remove, so that when the plate is rolled up it becomes a fine scum and the work is destroyed. Another point to consider is the thickness of the bichromate albumen film in relation to the exposure ; this must be of such duration that the light action penetrates through the sensitive coating to the bottom of the grain to ensure that it thoroughly adheres to the metal. On the other hand, if the film is thick a longer exposure is necessary to allow the light to penetrate through the film to the plate, and in consequence of this prolonged exposure the light rays become diffracted, as was shown by the diagram on the screen, and the lines on the plate become broader than are actually on the negative.

Col. Craster referred to the film on the plate as consisting of fish-glue and a little albumen. I do not think that fish-glue in the formula is the best for fine work ; in practice it tends to give a fuller line than does albumen, and often the plate will not wear as well. From my own observation I find that most operators have a pet formula from which they think they can get the best results, and probably do get excellent results because experience has taught them to adapt their methods of working to suit the formula. There seems to be no set standard formula which all could follow ; local conditions of working bring the personal element into account, and where one man under given conditions will succeed, another may fail.

In compounding the sensitive solution there is another important matter to consider. When the plate is coated it is put into a whirler which is rotated at a given speed to give an even coating over the whole surface of the plate. If the rotation is too rapid the solution is thrown off and the film becomes thin, the points of the grained plate protrude through the film, and give a bad plate. On the other hand, if the rotation is slow the film will be too thick ; it is therefore necessary to be sure that the rotation of the whirler is driven at a speed to suit whatever consistency the sensitive solution is made up to. If all the points I have referred to are carried out and the correct exposure made through a good negative, then the resulting plate should be absolutely perfect.

Mr. PHILIP (Messrs. Geo. Philip & Son, Ltd.) : I should like to associate myself in the appreciation of the interesting address which we have had. As a private publisher it rather makes one's mouth water to hear of a lens costing £3000. But such things are not altogether for the more modest private geographical institutions of this country. I should also like to express a word of regret at the passing of the art of copper engraving for map purposes. I agree that no mechanical or mainly mechanical process can equal some of the

finest examples of engraved map-making done in past days by the Ordnance Survey and even by private firms. There is one practical question I wish to ask Col. Craster, and that is in regard to the medium which he uses—zinc. We have tried zinc for printing, and although we use the same helio process and the Vandyke process as are used on a much larger scale in the Ordnance Survey, we find that for many reasons aluminium is a better medium for printing. For one thing, the tendency to scum which was referred to by Mr. Crawford is, according to our experience, almost eliminated. Again, we find that the tendency of the work to thicken up by the helio process is rather reversed in the course of printing, and that the work tends to fine out actually when it is running through the machine and the work is being printed from the aluminium plate.

Nothing was said with regard to the question of distortion after the helio process was over. It would be interesting, though it is beyond the limits of the address, to know whether the Ordnance Survey adopts any special measures for trying to preserve the shape and scale of the maps after they are actually printed. Using as we do transfers from copper plates, we find that we have little difficulty in preserving a uniform humidity in the printing room by the use of hygrometers and other means, and so getting down transfers to their exact size on to the plate and their colour stones or plates in perfect register. But the paper tends, of course, after it is once printed, either to expand or to contract according to the humidity and temperature of the place where the printed map is ; and as private publishers we find, when a number of Ordnance sheets have to be joined up by mounting, a very great mechanical difficulty in fitting the individual sheets together ; and indeed, owing to the variability in stretching, a certain amount of " faking " is often necessary, which for the purposes of land survey work must be very serious. That is a question to which it would be very interesting to have an answer.

Mr. HINKS : I had intended to ask Col. Craster whether any attempt had been made at Southampton to try the Roussilhe method of rectification when distortion occurred. I know, of course, that the distortion in an air photograph, for which that particular method was invented, is not altogether the same kind of distortion as one gets in drawings due to changes of moisture. But the Roussilhe method, introduced a rather novel optical principle, due to an Austrian, Capt. Scheimpflug. I do not think until then we knew that it was possible by suitable geometrical arrangements to focus a drawing perfectly upon a screen not parallel to the drawing. Certainly I had not known that taught at Cambridge in geometrical optics ; it is quite a new and interesting theorem, and may be of some use in photographing distorted drawings.

We have not heard from Col. Craster how many pulls can be got from a zinc plate. I have always understood from the lithographers for the *Geographical Journal* that they use stone because we have such large editions to be printed. They say they cannot possibly print more than a couple of thousand from a zinc plate and get good results. I do not know whether that is true. It is one of the things I should like, as Editor of the *Journal*, to find out.

Then there is the question of artificial *versus* natural illumination in photographing. Col. Craster has not mentioned the fact that, owing to the necessarily increased obliquity at which the light passes to a corner of a plate through a lens, there is serious falling off in the illumination in the corners of the plate, which so long as the plate is illuminated uniformly by natural light cannot be got over. It does seem to me that that is a possible argument in favour of

using artificial light, with which you could clearly get more intense artificial light at the corners, and you might be able to balance that falling off due to the lens.

When Col. Jack said that the printing from these plates was as good as the printing from the engraved plates, I suppose he meant as good as printing from transfers from the engraved plate.

Col. JACK: Yes; nothing could come up to the original engraved plate.

Mr. HINKS: That is quite a different thing. Then we are told that the best way to preserve the map is in the form of the glass negative. I was interested to speculate on the merits of making the thing that you consider permanent of such a fragile material as glass, and would like to know if negatives are ever broken. Finally, there is one point with regard to type. Col. Craster showed a style of type which has been adopted for the 25-inch maps because it can be reproduced without losing any of its fine characteristics, and it was called "lining Grotesque." Printers have a curious jargon in the choice of names for their type, but I had not previously realized why they call a type "Grotesque" which is of the plainest possible kind. It must be because it is so ugly. The hair lines are particularly fine in the modern-style type which the Ordnance Survey have always used in stamping the names, and I would like to ask whether it is not possible rather than to abolish the *serif* altogether, which adds so much to the character of the type, to use one of the better and heavier old-style types, perhaps Plantin, which I believe would have *serifs* that are not so fine as to disappear but yet would be infinitely more beautiful than the Grotesque which has, unfortunately, been adopted at the moment for 25-inch maps.

Col. J. E. E. CRASTER: I have nothing to add to what Col. Winterbotham has said, and as Col. Jack's subordinate it would be out of place for me to edit his remarks. Mr. Crawford has gone into some detail with regard to the process, and I have nothing, therefore, to add to what he has said. Of course we try to coat the plate completely with our film and try to get the film as thin as we can.

With regard to the use of albumen only, that was tried a good many years ago by the Ordnance Survey, and, as far as I remember the records, we had great difficulty in getting it off the plate once we got it on. It gave too much trouble, so we adopted a mixture of fish-glue and albumen instead of pure albumen. However, I am quite prepared to try albumen again and see what we can get.

With regard to the question of vibration: I think we are extraordinarily lucky at Southampton. We get no vibration. The building stands a long distance away from any heavy traffic, and I think that we have no machinery running anywhere near. I think our success in eliminating vibration is due to the fact that the vibration is not there. In the Ordnance Survey office in Dublin, before we handed it over we had great trouble at one time on account of vibration. There was a gas engine running a long distance away, and we traced vibration to it. We got rid of it by isolating the concrete floor on which the camera and copyboard stood. We cut right through the concrete floor down into the boulder clay below and filled in the space with sawdust, and that entirely eliminated the vibration. If you can find out where vibration comes from and carry out an insulation of that sort, you can probably eliminate it; but still there is that trouble. Undoubtedly, it would be extraordinarily hard to use a big camera in London.

With regard to Mr. Philip's question as to zinc *versus* aluminium plates.

We tried aluminium plates, and in our opinion they did not produce finer work than zinc, besides which they had these two disadvantages : the grain did not stand so long ; the plate was inclined to take a polish in the machine. That was our experience. We may have been unlucky. Another thing we disliked about them was that they were springy, whilst a zinc plate is soft and has rather the qualities of a sheet of lead. If it gets bent it is possible to bend it back again to the flat shape, whereas if an aluminium plate gets bent it is impossible to straighten it out. That was one of our chief objections to it. I know that many people like the aluminium plate best, but our experience does not favour it.

Mr. Philip also asked a question with regard to the distortion of maps after printing. During the war we had to buy any paper we could get, with the result that we got papers some of which expanded in the length and others in the width of the sheet ; and if you try to mount a map which expands in the length alongside another map which expands in the breadth you have appalling trouble. The only way is to ask us to print you another copy of one or the other on the same paper as the first, so that you get two sheets of paper which are the same, and thus when they are wetted they both expand in the same direction.

With regard to Mr. Hinks' question in connection with the Roussilhe method. The apparatus, I imagine, will be very costly, because it has to deal with photographs which are at present dealt with by an 8-inch lens, so that I believe it will be necessary to have another lens of the same size, though it may be possible to use the same lens.

Mr. HINKS : I believe it is only a matter of altering the carriages.

Col. CRASTER : I must admit, however, that we have not fairly considered that question, so that I cannot give any satisfactory answer on that point. I perhaps made too much of distortion. It occurs about once a fortnight, or, in other words, perhaps 2 per cent. of our maps give real trouble through distortion.

I have been asked how many pulls it is possible to get from a zinc plate. If we are printing an edition we generally make a new zinc plate from an existing negative, and we expect it to print about 10,000 copies at least. Then when that is done, for the next edition we probably made another new plate. Plates can be made within an hour, and it is therefore very simple. Of course there are accidents ; you may get a badly grained plate or one with a flaw, or something goes wrong and the plate may fail before it has printed five copies. A good one should run to 10,000 on an offset machine. I would not guarantee that for a flat bed.

Mr. CRAWFORD : I may add that I am running a job now, and we get 10,000 off quite comfortably and roll up the plate and put it away for another edition. It all depends upon the material used and how the plate is treated.

Col. CRASTER : Mr. Hinks has asked a question with regard to illuminating the corners of the map. What we have found in actual practice is that there must be uniform illumination all over the map, and the light must not shine directly on the map, but across from both sides so that there is no direct beam thrown on to the map. We do get a falling off at the corners with our lens, but I am afraid that if we illuminate the corners that would land us in more serious trouble. We should get a shine on the negative—a reflection from the map which would upset our negative. We know so well from experience that we must light the maps by the side that I have never really made the experiment of shining a spot light on them.

With regard to the permanency of the glass negatives, we have extra-

ordinarily few breakages. I have been in charge of the work at Southampton for about three years, and no important negative has been broken during that time. We have had minor breakages of unimportant negatives. A man scraping the film off a negative will sometimes break the plate, but that is of no significance. However, we take very great care of the negatives and carry them about as little as possible from one room to another. The glass is pretty thick; it takes a good deal to break it.

With regard to the *sans serif* type that is being adopted for the bulk of type on the 25-inch maps, there will be lots of other types as well, but it will increase the speed and decrease the cost of producing the 25-inch map, and that is a very important point. If a man wants a 25-inch map he wants it very quickly, as a rule, for a lawsuit, and the sooner we can get it out after the map has been revised the better.

The PRESIDENT: We have had a most interesting discussion on a subject of great interest, and much light has been thrown upon the process of map reproduction. The outcome seems to me to be that while the technique of the process has certainly now reached a very high standard, the final word has by no means yet been said. It is clear that there are differences of opinion amongst the experts upon questions of detail. Though I ventured to throw out a suggestion that some one might give his experience on the question of the photogravure process for map reproduction, it seemed to me that amongst the speakers there was a conspiracy of silence on that point, and I remain as much in the dark on that particular question as I was before the afternoon commenced. I assume, therefore, that in the opinion of the experts the process is not of any real value for the reproduction of really accurate maps. That may be so or not. In any case we are all much indebted to Col. Craster for the excellent paper which he gave us to start the discussion, and I hope that the interest which he found taken by the audience in the subject which he laid before us will, to some extent, recompense him for the trouble and the time which he has so kindly given to instructing us this afternoon. I offer him the thanks of this audience for having done so.