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VI.—*The Application of Photography to the Reproduction of Maps and Plans by Photo-mechanical and other processes.*—By Capt. J. Waterhouse, B. S. C., *Assistant Surveyor-General of India.*

This paper was originally submitted to the Geographical Congress at Paris in 1875, but as the Proceedings of the Congress have not been published and the paper may be of interest to Members of the Society, as giving an account of the photographic operations for the reproduction of maps, now so largely employed in this country, I have carefully revised and to a great extent re-written it, so as to bring the information up to date and hope that it may not be considered too much wanting in novelty or too technical for the Journal.

I. Introduction.

Among the many useful and important artistic and scientific applications of photography, one of the most valuable is the reproduction by its means, in absolute facsimile, of maps and plans, speedily and cheaply and on any scale—either the same, larger, or smaller. So fully are these advantages appreciated, that most civilized States now possess special photographic studios for the reproduction of maps, plans, &c., for fiscal, military and other purposes.

Before the introduction of lithography, about the beginning of the present century, the only means by which maps, or indeed, pictorial subjects of any kind, could be reproduced, was by engraving on metal plates or on wood, both tedious and expensive methods.

With the invention of lithography, a new impetus was given to cartography by the comparative ease with which maps could be produced and multiplied by direct drawing or transfer on stone. The young art was, however, scarcely out of its cradle when Joseph Nicéphore Niepce, of Chalons-sur-Saone, experimenting unsuccessfully in endeavouring to find a substitute for lithographic stone, conceived the happy idea of obtaining images on metal plates by the sole agency of light upon thin films of asphaltum or bitumen of Judæa—and thus produced the first permanent photographs by a method of heliographic engraving, which, with a few modifications, still serves to produce excellent results; and it is worthy of remark in connection with our subject that Niepce's first essays were in reproducing engravings.

Since these first essays of Niepce, the idea of superseding the slow and laborious hand-work of the lithographic draftsman and engraver by the quicker, cheaper and more accurate processes of photography, has been steadily kept in view, and various modes of engraving, both for copper-plate and surface-printing, and of lithography by the aid of photography, as well as other special photo-mechanical processes, have been introduced from time to time with more or less success, till at the present time these methods have taken a high and important position among the graphic arts, and as they steadily progress towards perfection, are rapidly extending their artistic, scientific and industrial applications.

The attention of cartographers was very soon drawn to the advantages that might be gained by the employment of photography for the reproduction of maps and plans, but for some time progress in this direction was hindered by the difficulty of obtaining accurate images, free from the distortions caused by imperfect construction of the photographic lenses then employed. The first serious attempt to carry out the method practically appears to have been made, in 1855, by Colonel Sir Henry James, R. E., Director of the Ordnance Survey of Great Britain and Ireland, with the object of obtaining accurate reductions from the large-scale surveys more expeditiously and with more economy than could be done by means of the pantograph.

The result proved incontestably the great value of photography for this purpose and the enormous saving in time and money that could be effected by its use. The possibility of producing absolutely accurate photographic reductions was questioned in Parliament, but Sir Henry James satisfactorily showed that the employment of photography produced reductions more accurate than could be obtained by any method previously in use; that the maximum amount of error could scarcely be perceived, and was much within the limit of the expansion and contraction of paper under ordinary atmospheric changes—which was all that could be desired.

For some time, however, the use of photography in the Ordnance Survey Office appears to have been limited to obtaining accurate reduced prints for the engravers to trace from on to their copper-plates, and was not extended to producing maps for publication, owing to the expense and comparative slowness of production of photographic silver prints, compared with the lithographic or copper-plate impressions, to say nothing of their want of permanence.

Experiments were next made with some of the so-called carbon processes, then recently discovered in France by Poitevin and first worked in England by Pouncy, with the object of transferring the photographic design at once on to the copper-plate, instead of tracing from the photographs by hand. The results obtained were not very satisfactory and a trial was made of Mr. Asser's photolithographic process, which had been published shortly before. Although this process was not found quite adapted to the purpose intended, the advantages of a method whereby facsimile prints in lithographic ink might be obtained and transferred to zinc or stone, so as to permit of a large number of copies to be printed off as easily as from an ordinary lithographic transfer drawing, and with precisely the same advantages in respect to cheapness and permanence, were obvious; and in 1860, after several trials, Captain A. de Courcy Scott, R. E., who was in charge of the photographic operations at Southampton, perfected the process of photozincography, which has since been employed with so much success and advantage at the Ordnance Survey Office, Southampton, and in this country at the Survey Offices in Calcutta, Dehra Dún, Púna and Madras, as well as at other public and private institutions in other parts of the world.

By a curious coincidence, at the very time when this process was being worked out in England, Mr. W. Osborne, of Melbourne, Australia, independently perfected an almost identically similar process of photolithography, which has been extensively used in the Crown Lands Offices of Victoria and Adelaide for reproducing the maps of the Australian Surveys, and has also been worked commercially by Mr. Osborne in Europe and America.

These two processes, appear to have been the first instances of the practical application of photography to the reproduction and multiplication of maps for publication. They still remain, however, very extensively used, and are by the simplicity, cheapness and rapidity of their operations and the facilities they offer for the reproduction of maps of large size, of greater practical value than other processes which have since been brought forward with the same object, and are perhaps capable of producing finer results within the limits of a single negative.

In India, the ever-increasing wants in the way of communications by rail, road and river, and the rapid extension of irrigation and other

engineering projects, as well as the ordinary military, administrative and fiscal requirements make the early production of accurate maps a matter of very great necessity and importance, and as skilled lithographic draftsmen and engravers are scarcely to be obtained and must be trained as required, or brought from Europe at great expense, the subject of photographic reproduction as a means of quickly producing and publishing copies of the original maps of the Surveys, is much more important in this country than it is in Europe or other countries where skilled cartographic lithographers and engravers are comparatively numerous.

The success that had attended the introduction of photography at the Ordnance Survey Office for the reproduction and reduction of maps immediately attracted the notice of the Surveyor General of India, and the services of two trained sappers, with the necessary apparatus, having been obtained from England, a small beginning was made in Calcutta in 1862. Owing to difficulties experienced in working photolithography in the peculiar climate of Calcutta, and the unsuitability of the original maps for reproduction by the process, owing to their being coloured and brush-shaded, little advance was made in the practical working of photolithography or photozincography in India till 1865, when Mr. J. B. N. Hennessey, of the Great Trigonometrical Survey, who had devoted part of his furlough in England to going through a practical course of instruction in photozincography at the Ordnance Survey Office, Southampton, fairly established the process at the Office of the Superintendent of the Great Trigonometrical Survey at Dehra Dún. I and other officers of the Survey Department were trained under Mr. Hennessey, and, in 1867, photozincography was finally started in Calcutta by Capt. A. B. Melville, who officiated for me during my absence on furlough, and since 1869 it has been carried on under my own supervision. Photozincographic offices have also been established under the Bombay Government at Púna, and at the Revenue Survey Office in Madras for the reproduction of the maps of the Revenue and Settlement Surveys in those Presidencies as well as miscellaneous work for other departments. In both of these offices the Southampton process of photozincography is used with a few modifications, but in Madras photolithography is also used with equally good results, and is, I am told, preferred for very fine work.

Before the introduction of photography the publication of the results of the Surveys by the Surveyor General's Office could only be accomplished by the ordinary methods of lithography and engraving; and though much good work was done in the former manner by the very limited native agency available in this country, many maps had to be sent to England to be lithographed, while the whole of the engraving connected with the Atlas of India, on the scale of 4 miles to one inch, was done in England under considerable disadvantages. Even with this help it was found quite impossible that

the publication could keep pace with the surveys, and the consequence was that the record rooms became filled with valuable materials that often could not be turned to practical account till they had become antiquated and out of date. Now, on the contrary, by the aid of photozincography, the publishing branches are able to keep pace with the progress of the Surveys so closely that as a rule each season's mapping of all the 1-inch Topographical and some of the Revenue Surveys is reproduced and published before the drawing of the following season's maps is taken in hand. An immense amount of work is thus done that could never have been undertaken by lithography and engraving alone, even though the transfer of the engraving of the Atlas of India to Calcutta has greatly facilitated the early publication of the latest additions to the Atlas year by year. And not only are the ordinary departmental publications thus hastened, but a very large number of miscellaneous maps and drawings are reproduced specially for the use of other departments of the public service.

The following table of the work executed by the Photographic Branch of the Surveyor General's Office, Calcutta, during the year 1877, will give an idea of the very large extent to which photography is being used for the reproduction and publication of the results of the Imperial Surveys and other miscellaneous demands.

	Sections or Sheets.	Negative Plates.	Carbon Prints.	Silver Prints.	Photo:—Transfer Prints.	Transfers to Zinc or Stone.	Number of Pulls.	Number of Sheets Printed.
Topographical Maps, ...	167	272	..	218	241	106	20,775	21,215
Revenue Survey Maps,....	233	263	..	..	297	71	22,370	18,320
District Maps, ...	6	22	..	..	8	3	6,364	5,084
General Maps, ...	42	199	..	46	176	44	9,359	6,629
City and Cantonment Plans,	59	104	..	63	122	37	8,580	8,580
Miscellaneous Maps, &c., ..	362	510	..	536	507	190	57,138	82,515
Proofs,.....	..	..	..	..	..	..	5,932	..
Photos. of Life Convicts, ..	..	..	348	..	..	..	..	..
Cadastral Maps, Bengal, ..	56	..	..	..	..	56	2,800	2,800
Total,.....	925	1,370	348	863	1,351	507	133,618	145,143
Cadastral Maps, N. W. P.,	2,113	3,973	..	..	4,047	2,218	99,450	99,450
Grand Total,.....	3,038	5,343*	348	863	5,398†	2,725	233,068	244,593

* 20,962·00 square feet. † 22,027·40 square feet.

In the Great Trigonometrical Survey Office at Dehra Dún, during the year 1876-77, 117 maps and 30 charts, besides miscellaneous diagrams were photographed, and 25,529 copies printed from them; 297 blue prints and silver prints were also made.

At the Govt. Photozincographic Office, Púna, during the same year, the number of negatives taken was 2,745, the number of maps photozincographed was 1,798, and the number of copies printed off (including copies of 79 lithographs) was 74,739. Since the formation of the office, in 1867, to the present time 9,100 maps have been photozincographed.

The specific advantages to be gained by the use of photography for the reproduction of maps and plans are:

1. Rapidity of production and multiplication, especially when employed for copying subjects containing close and intricate details. The gain varies according to the amount of detail and the time that would be taken by a skilled draughtsman or engraver to make the copy by hand. For instance, a highly finished map that would take several months to lithograph or engrave, may by the aid of photography be copied and some hundreds of copies printed off within a week.

2. The perfect fidelity with which the most delicately minute and intricate details are copied. The most skilful and careful draughtsman is liable to make errors in copying, and never can attain the same accuracy of delineation, especially of minute objects, as is obtained with the camera.

3. The facility with which copies may be obtained on scales larger or smaller than the original. The extent to which this may be taken advantage of depends very much upon the object in view as well as upon the style of the original, and the relative thickness and size of the lines and details composing it; but notwithstanding certain drawbacks and inconveniences it may sometimes be attended with, this facility of enlarging or reducing the scale of an original drawing with the most perfect accuracy and with the absence of all personal error, is one of the most important advantages of photography, and its immense superiority in this respect over the pentagraph and other methods has been proved to be beyond question.

4. The comparative cheapness of the photographic methods. The relative cost of hand labour and photography is affected by several considerations, *e. g.*, the nature of the subject, the process employed, the number of copies made and the pay of the photographers as compared with that of draughtsmen. In most cases it will be found that when it is really an advantage to employ photography in reproducing maps for any particular purpose, the cost will be far less than it would be by employing hand labour.

Notwithstanding these advantages, the use of photography as a means of reproducing maps and plans for publication has not extended so much as

might have been expected, partly on account of defects inherent in photographic copying, and only to be overcome by great skill and long experience on the part of the photographer, and partly owing to the difficulty of making draughtsmen fully understand the requirements to be fulfilled when preparing maps to be reproduced by photography for publication, in order to produce satisfactory results, and that they must strictly refrain from using colour and draw the map neatly in black and white, so that every line may be reproduced of its proper strength, according as the map is to be copied on the same scale as the original or to be reduced.

It matters little how roughly drawn or highly coloured an original drawing or map may be, if it is intended to lithograph or engrave it, because a skilled lithographer or engraver can easily put it into proper and conventional form; but when such a drawing is handed to the photographer he can only produce a facsimile of it with all its deficiencies—the coloured details hidden under a black mass of shade, the finer parts perhaps wanting altogether, the writing rough and broken, or so small as to be almost invisible, besides other defects caused by the unsuitableness of the drawing for reproduction by photography, and these defects are liable to be unduly attributed to the process.

These difficulties were felt in all their force when it was first determined to introduce photozincography for the publication of the maps of the Imperial Indian Surveys, because till that time these maps had been drawn in a very delicate, highly finished style, with many of the details on them coloured and the hill features shown by brush shading. It was soon seen that an entire change of style was necessary and that the original maps prepared specially for photographic reproduction, must be drawn in pen and ink lines alone, without colour or brush-shading. It was some time before the desired results were obtained, but after several years' experience a high degree of excellence has been attained in the preparation of original maps suitable for photographic reproduction, and now all maps of the above Surveys and most of the miscellaneous maps and drawings received from other departments are drawn with this object.

The change of style has been regretted by some as spoiling the beauty and finish of the maps, and the want of colour certainly has some drawbacks, but there can be no doubt that the necessity for drawing the original maps so that they may be fit for immediate publication has effected here, as it has also been found to do wherever photozincography or photolithography has been introduced, an immense improvement in the style of drawing of the manuscript maps as well as in the accurate delineation of the ground. The photozincographed copies as a rule appear somewhat coarse and rough when compared with good lithographs or engravings, but they possess the great advantage of being produced quickly and cheaply; while

being absolute facsimiles of the original maps submitted by the surveyors, they are entirely free from the errors that even the most careful draughtsman is liable to make when copying by hand, and they faithfully preserve the appearance and character of the ground exactly as delineated by the surveyor.

In most foreign topographical establishments, I believe, the principal use of photography is for making reductions, and not so much for the reproduction of maps on the same scale as the originals. In India, however, photozincography is very largely used for full-scale reproductions. Thus, the whole of the standard maps of the Topographical Surveys on the scale of 1-inch to the mile and the Cadastral village maps of the Revenue Survey, on the scales of 32 inches to the mile, for Bengal, and 16 inches to the mile, for the N.-W. Provinces, are reproduced on the same scale and are not reduced for publication on any smaller scale. In some cases, however, the surveys are made and drawn on the scale of two inches to a mile and are then reduced to one-inch, with a great improvement in the general appearance of the finished maps—reductions always appearing sharper and more highly finished than reproductions to scale. Some of the maps of the Revenue Surveys are reduced to the standard scale of 1-inch to the mile by a double reduction from the maps on the original scale of survey—4 inches to the mile. These are first photozincographed, in sections of convenient size, on the reduced scale of 2 inches to the mile and some prints are struck off in blue ink. Upon these blue prints, the draughtsman re-draws the map in a style suitable for a further reduction to one-half, leaving out all details not required on the 1-inch map and generalising the hill features, &c., so as to produce a proper effect when reduced. By the use of these blue prints, the labour of making a piecemeal reduction with the pantograph is saved, and the draughtsman can produce a more accurate result.

Silver print reductions to one-fourth of the standard 1-inch maps are made for the use of the engravers in preparing the sheets of the Atlas of India on the quarter-inch scale.

In the Photozincographic Offices at Púna and Madras more use appears to be made of reduction for the village maps than in the Calcutta Office.

The photographic processes applicable to the reproduction of maps are:

I.—*Photographic printing on Sensitive Papers.* In these methods prints are obtained on a sensitive surface of paper prepared with the salts of silver, platinum and iron, or with certain salts of chromium in conjunction with pigmented gelatine. In all of them the whole of the photographic operations connected with the printing have to be repeated for every impression.

II.—*Photo-lithography* or *Photo-zincography*, or the methods by which photographic image in greasy ink may be produced on, or transferred to, a lithographic stone or zinc plate and printed off in the lithographic press. The photographic operations cease with the production of the image in greasy ink, and the impressions are produced by the ordinary operations of lithographic printing. The use of these processes is, however, limited to the reproduction of subjects in line or dot, as they can only reproduce half tones in a very imperfect manner.

III.—*Photo-collotype*, or the method of producing a photographic image on a layer of gelatine applied on a suitable support, so that when the gelatine surface is moistened, impressions may be obtained from it in printing ink. By this method, also, a photographic image once produced on the printing surface of gelatine is capable of yielding some hundreds of impressions in the printing press; and instead of the subjects for reproduction being confined to those in dot or line, as in photo-zincography, any subject can be copied which is capable of giving a good photograph by the ordinary process of silver printing.

IV.—*Woodbury-type*, or the method whereby a photographic image is impressed into a soft metal plate, somewhat in the same manner as in the operation of nature-printing, forming a mould into which liquid coloured gelatine is poured and attached under pressure to a sheet of paper, thus yielding an image in which the lights and shades of the picture are formed by different thicknesses of coloured gelatine.

V.—*Heliography* or *Photo-engraving*, the method of obtaining on a metal plate a photographic image in intaglio capable of giving impressions in the copper-plate press. In this method the engraved plate once obtained serves for the impression of a large number of copies and may be indefinitely multiplied by electrotyping.

VI.—*Photo-typography*, or the method of obtaining by means of photography an image in relief on a metal plate, which may be mounted on a block to be set up with type and be printed in the ordinary printing press. These blocks may also be indefinitely multiplied by electrotyping in the same manner as ordinary woodcuts.

It will be observed that the five last-named processes all possess the great advantage that, once the photographic image has been obtained on the printing surface, the operations of printing can be accomplished by the same means and at the same rate as by the ordinary industrial methods. The printing may be performed by night or by day, quite independently of the agency of light, and requires no further chemical manipulations.

It would be beyond the scope of this paper to enter fully into the practical details of these various processes of photographic printing, as my object is merely to review those applicable to cartographic pur-

poses, and to give a summary of the principal methods that may be usefully employed with reference to the wants of the State or of private individuals, rather than to those of professional cartographers and map-publishers, though the latter may in many cases also find photography a useful auxiliary. Photographic methods can never entirely take the place of lithography or engraving by hand, either for public or private purposes, but their use may be advantageously extended. Those who wish for fuller details may consult the text-books by Abney, Carey Lea, Monckhoven, Vogel and others, and the special works referred to in this paper.

II. Preparation of the Original Drawing.

I have already adverted to the difficulty that has been found in this country and elsewhere in obtaining original drawings suitable for reproduction by photozincography, and to the fact that without a proper original drawing it is quite impossible to produce satisfactory results. Besides its principal use in reproducing maps of the Surveys, photozincography is very largely utilised in India by engineers for the reproduction of their plans and drawings, and by other public officers for an immense variety of miscellaneous maps and plans, and as we were constantly asked to photozincograph subjects utterly unsuitable to the process, a set of rules for the preparation of the original drawings for reproduction by photozincography was drawn up under General Thuillier's direction and published in the official Gazettes all over India, and the result has been a great improvement in the execution of the drawings we receive for reproduction.

The rules are as follows:—

1. All drawings should be on white, smooth-surfaced paper, free from dirt, pencil marks, creases and wrinkles. When possible they should remain stretched on the drawing-board.

2. The Indian ink should be freshly rubbed down and give good *black* lines, free from glaze.

3. The lines should be firm and cleanly drawn—not too fine or too close together. They must be quite *black*, and light effects must be produced by fine and open black lines, and never by the use of *pale* ink. Thick lines in the printing and borders of maps should be well filled in. Pencil marks should be carefully removed, so as not to injure the blackness and firmness of the lines.

4. All cross-hatching and shading should be as open and clear as possible, and the lines composing it firm and not too fine. Intensity of shade must be shown rather by an increase in the thickness of the lines than by placing them closer together, in order that the intermediate spaces may not become blocked up when transferred to zinc. It is better not to rule the shading of mechanical and architectural section-drawings, but to

show the shaded parts by a light tint of blue, violet, or *aniline* red (fuschine or roseine). These parts will reproduce white, and can have a ruled tint transferred on the stone or zinc in the usual way, which will give a much neater appearance.

5. In plans or drawings intended for photozincography, *washes* of any colour except very pale blue, violet, or aniline red, are absolutely inadmissible. Outlines, may, however, be drawn, if necessary, in any strong red, brown, yellow, orange or green pigment which will reproduce black. Any details required to be shown in the original, but not in the copy, may be drawn in pale blue, violet, or aniline red. Details that are not required to be reproduced may be painted out with Chinese white.

6. River courses, lakes and tanks should be left blank, and not filled in with fine lines. They may be indicated by a pale wash of *blue* without detriment to their reproduction.

7. When drawings are to be reduced care must be taken to draw the lines, lettering, and detail of sufficient thickness and size relatively to the scale of reduction, so that they may not be lost or illegible when reduced. Sufficient space must also be left between the lines to prevent subsequent blocking up.

8. When possible, drawings should be made on a larger scale than they are required to be copied. Photographic reductions are always sharper and firmer than reproductions to the same scale, and defects in drawing are lessened by reduction.

9. Where plans or drawings to scale are to be reduced, the scale should be given in terms of a single unit of measurement and not as relative to any second unit. Thus, the scale on a map drawn on the scale of 4 miles to an inch for reduction to 16 miles to an inch, should be shown simply as a "scale of miles."

10. As photography produces a more or less perfect *facsimile* of the original drawing, it is essential that drawings intended for publication should be complete and finished in every respect before they are made over to the photographer. The drawing, printing of names, &c., should be in as neat a style as possible, and not require to be altered or touched up. The hair-strokes of the printing should not be too fine.

The foregoing rules may be summed up in a few words :—WHITE-PAPER, BLACK-INK, and FIRM OPEN DRAWING ; and as success in the after processes depends entirely upon the perfection of the original drawing and its capability of giving a negative on which the ground is perfectly opaque while the lines are quite clear and as transparent as the bare glass, these essentials must be most carefully observed. Their neglect will entail failure and disappointment.

For drawings intended for reproduction by the collotype methods these

rules are equally applicable, especially No. 7, and there is even more necessity for perfect cleanliness of the paper and neatness and finish of the drawing, because the faintest tints will be reproduced by the gelatine printing surface and corrections cannot be made on it, as they can on zinc, stone or copper. For this reason also, the greatest care must be taken to complete the drawing in every respect before it is given to be reproduced. Drawings in line may be finer and more delicate than for photolithography, but still must not be so fine as to interfere with the obtaining of a perfectly dense and opaque negative, otherwise the ground of the print will appear dirty and stained. Pale ink may be used when necessary for effect, but not more than is really requisite. Colour may be used to any extent, having always due regard to the photographic effect when reproduced. On account of the difficulty of photographing certain colours so as to produce the same effect as in the original picture, the best results will be produced from drawings specially prepared in monochrome, such as Indian ink or sepia.

In the case of drawings for any special purpose or not intended for publication, the above rules may be relaxed, but the general principles laid down should be observed, as far as practicable, if the best results are desired.

When drawings are prepared specially for photographic reproduction, there need be no difficulty in taking all the precautions necessary for producing good results. It often happens, however, that the photographer is called upon to reproduce drawings, lithographs, or old MSS., printed records, or engravings, which either may never have been suitable for the purpose, or, if suitable when fresh, have become dirty and stained by age. Herr Scamoni, the skilful Chief of the Photographic Department of the Imperial State Paper Office at St. Petersburg, has given some useful hints on the treatment of such subjects under these circumstances.*

"Yellow, or otherwise objectionable, spots should be carefully covered over in the spaces between the lines with Chinese white, and whenever possible the lines should be strengthened in parts where they appear weak."

"Lithographs and engravings may be bleached, by immersion in a solution of chloride of lime, or *Eau de Javelle*, (1 to 10 or 15 of water), then soaked in water for some hours, after which they are treated with a weak solution of hyposulphite of soda and finally well rinsed in clean water."

"Fresh grease stains may be removed with chloroform, benzine and ether, or with a weak alkaline solution of caustic potash or its carbonate."

"Old grease stains may be removed with a more or less strong solution of potash, applied at the back of the subject."

* *Handbuch der Heliographie*, p. 67.

"Iron mould and ink spots may be taken out with a solution of oxalic acid or salts of sorrel."

When tracings are made on paper or vellum cloth to be reproduced without the aid of the camera, special care must be taken to keep the back of the drawing clean, and to choose paper or cloth free from stains and of as even a texture as possible.

Originals drawn on rough paper may be smoothed in a copper plate press, and, if dirty, should be carefully cleaned with india-rubber or bread.

III. The Production of the Negative.

After the due preparation of the original, the production of the negative is a point of the utmost importance, and may well be considered by itself before proceeding to the consideration of the various processes of photographic printing.

In order to obtain the most satisfactory results for photolithography, photozincography, or any other process specially applicable to line subjects, the negative must be perfectly sharp all over, free from distortion and possess the greatest amount of contrast between the lines and the ground. If care is taken to produce good negatives from suitable originals, results may be obtained which will compare with ordinary lithographs and engravings for sharpness and delicacy. The difference in the results of working with good negatives or bad ones is incredible; with a good negative from a good original every thing works well, but with a bad negative from a faulty original all kinds of difficulties may be encountered, and the attainment of a passable result is almost a matter of chance.

The first thing is to arrange the plan so that it may be copied without any distortion and be quite sharp all over.

To ensure freedom from distortion, the lens employed must give an image quite free from all curvature of the marginal lines of a rectangle. In practice the most suitable forms have been found to be the 'Rectilinear' of Dallmeyer; the 'Doublet' of Ross; 'Aplanatic' of Steinheil and others on the same principle. The lenses known as triple combinations are also good. In the Surveyor General's Office, Calcutta, Dallmeyer's Rapid Rectilinears are used and found to answer well. The lens should be worked well within its power, so as to use the most central rays; and to secure the sharpness of the image all over the plate, a small stop or diaphragm should be used.

The plan must be placed so as to be evenly illuminated by a good strong light falling as horizontally as possible, in order to avoid shadows being thrown by the grain of the paper, and thus diminishing the even opacity of the ground of the negative.

The apparatus for supporting the plans varies according to the nature of the work required, and may either be a perfectly smooth board fixed permanently in a truly vertical position against a wall or other support, a form which is very suitable when large plans have to be copied or reduced; or it may consist of a frame large enough to take a certain size of map and capable of being adjusted in various ways so as to move up and down in a vertical plane or horizontally right and left, so that different parts of the plan may be brought in front of the camera without moving the plan on the board.* In any case, arrangements must exist, either in the plan-board or in the camera-stand, for making the plane of the map or plan to be copied exactly parallel to the plane of the sensitive plate in the camera.

The map must be attached to the plan-board so that it may lie perfectly flat and free from ridges. This is best secured by placing in front of it a sheet of glass which is fastened down on the board with pins at the corners. Or a glazed frame may be used for holding plans of a medium size. In either of these cases care must be taken to avoid any reflection from light objects in front of the plan-board.

It is convenient to have the plan-board and the focussing glass of the camera ruled in squares of 1 inch or other convenient size, in order to at once test the perfect parallelism of the sensitive plate and the plan-board.

When the work is confined to the reproduction or reduction of maps or other subjects of one fixed size on a single plate, it will be found convenient to draw a rectangle of the required size on the ground glass of the camera. When the image of the subject exactly fills this rectangle the adjustments of focus and parallelism will be correct.

The camera used for reproduction to scale should be at least of sufficient length to draw out to twice the equivalent focal length of the largest lens it is to be used with, and may be furnished with cone fronts to give further extension if necessary. With large cameras of a long range of focus it will be found convenient to have the back part of the camera fixed and the front part carrying the lens moveable, so as to enable the operator to focus conveniently. The camera may be fixed on a stand furnished with adjustments for moving it horizontally right or left, and have a tilting motion up and down, in order to adjust the camera perfectly level, or tilt it slightly so as to correct any want of verticality of the plan-board. The camera-stand should run upon rails fixed in the ground at right angles to the wall carrying the plan-board, thus enabling the distance of the camera from the plan-board to be easily and accurately adjusted according to the scale required. When using a reversing mirror or prism for taking re-

* See my '*Report on the Cartographic Applications of Photography*,' plates V, VII and X, and Sir H. James' '*Photozincography*', plates I and II.

versed negatives for collotype and other purposes, it is a good plan, when possible, to have an arrangement for laying the plan horizontally under the lens at any convenient distance from it.

The whole of the apparatus connected with the camera and plan-board must be rigid and firmly fixed, so as to be free from vibration. The slightest vibration is sufficient to destroy the perfect sharpness of the image. In the glass-house attached to the Photographic Branch of the Surveyor General's Office here, I have endeavoured, and I think with success, to overcome all vibration caused by carriages passing in the street close by, by dividing the floor of the camera-room into isolated blocks resting on a bed of sand, so that each camera shall stand by itself on a block isolated from adjoining blocks and from the walls and floor of the building The plan-boards are fixed on a separate wall quite isolated from the walls of the building.

Plans may be copied either in the open air or under shelter—coloured and old stained manuscripts, maps or drawings are better copied in full sunlight. The glass-house I have constructed at the Surveyor General's Office faces the south and is glazed with ground glass, so that a strong diffused light may be thrown upon the plan-boards. When circumstances permit, it is well to have the camera and plan-board mounted on a firm stand working on a pivot, so that, as the day wears on, the position of the plan-boards may be changed so as always to face the sun. I adopted this arrangement at the Trigonometrical Survey Office, Dehra Dun, and I believe it has many advantages over the fixed glass-house rendered necessary in Calcutta by the constant wind and dust, and the greater necessity of being able to carry on work without interruption at all times of the year.

The negatives of maps &c., drawn in line only, for reproduction by photozincography, are taken by the ordinary wet collodion process with iron development, modified so as to secure the greatest transparence in the lines and density of the ground; but as the ordinary wet collodion process by itself will not give all the intensity required to produce an almost opaque ground, it is obtained by intensifying the negative in the usual way with pyrogallic acid and silver, after fixing; then treating it with a saturated solution of bichloride of mercury till the film becomes white, and finally applying a dilute solution of hydrosulphate of ammonia, which instantly changes the colour of the film to a dense black or brown throughout. The negative is afterwards varnished with a resinous varnish, or flowed over, while wet, with a solution of gum or gelatine and allowed to dry. All defects, pin-marks &c., are then stopped out with Indian ink or black varnish. In taking the large negatives on plates 32×24, that we are now producing for copying the maps of the Cadastral Surveys, it has been found that the first intensification may be produced by washing the plate after the first develop-

ment and applying a weak solution of nitrate of silver followed by a second application of the iron developer.

Other methods of obtaining the extra density required for these negatives have been proposed and are in use,* but, notwithstanding several inconveniences arising from the use of bichloride of mercury and hydrosulphate of ammonia, the above appears to be the best and most certain when working on the large scale.

When maps are not drawn entirely in pen and ink but have the hills brush shaded, and it is desired to reproduce them by the collotype or engraving processes, great care and skill are required on the part of the photographer to get the ground of the negative dense enough to give a perfectly clean impression in the white parts of the map, and at the same time prevent the grain of the paper from showing and give the faintest tints of the shading their proper value. Coloured maps also give a good deal of trouble, and when allowable the colour should be washed off as much as possible before the negatives are taken. Colours may sometimes be removed by chemical means, but there is risk of injury to the original.

In many of the processes about to be described it is necessary to use a negative which instead of giving an image reading the same way as the original shall give it reversed as to right and left. There are several methods of obtaining these reversed negatives.

(1.) By coating the original unreversed negative with a thick transfer collodion,† or a layer of gelatine, and then stripping off the film and, either laying it down again on a sheet of glass in a reversed position, or using it as a film negative which may be used for giving both reversed or unreversed images. This method is practical and useful, but is not suitable for map work on account of the liability to contraction and distortion of the image. There is also difficulty in keeping the film negatives flat, and they have been found to become brittle and perish very soon in this climate.

(2.) By turning the sensitive plate in the camera, so that the light acts, through the glass, on the back surface of the film. This method is also practical, simple and useful, but requires care in the selection of glass plates free from scratches, &c., and in wiping the back of the plate before it is put in the camera. It is used in the Belgian Topographical Bureau with dry tannin plates, but I have not found it suitable for reproducing very fine map-work on wet plates.

(3.) By placing a reversing mirror or prism in front of the lens—the image thus passes through the lens reversed and is impressed directly on the sensitive plate. This is one of the simplest and most effectual of all methods. If a mirror is used it should be one silvered by depositing silver

* See Abney, *Instruction in Photography*, p. 22.

† See the same work, p. 160.

on the front surface and should be large enough not to cut off the oblique rays entering the lens. A large solid reversing prism is expensive and heavy, but for moderate sizes an efficient instrument may be made by building up a hollow prism with glass plates and filling it with a transparent fluid having a suitable index of refraction. M. Derogy, of Paris, has just invented an ingenious and economical method of employing a reversing prism by placing a small prism between the lenses. I have not seen any results of this arrangement, but it seems likely to be as effective as it is simple.

(4.) By what is known as the 'dusting on' or 'powder' process. A glass plate is coated with a mixture of gum, sugar and bichromate of potash dissolved in water, thoroughly dried with heat, and then exposed to light under a negative. After removal from the printing frame, the gummy film is dusted over with very fine plumbago which adheres to it in inverse proportion to the action of light, *i. e.*, those parts on which the light has acted refuse the powder in proportion to the intensity of the action of light, while the protected parts, attracting moisture from the air and so becoming 'tacky,' take the powder readily, and thus an exact transcript of the original negative is produced, but reversed. This method is simple and effective and seems to be one of the best that can be employed when a mirror or prism is not available, or when, as is frequently the case, the reversed negative can only be obtained by copying from a single original unreversed negative.

(5.) By making a copy, either in the camera or by contact, on a film of collodio-bromide of silver. The image is developed as usual by the alkaline method, and then treated with nitric acid which dissolves the reduced silver in the exposed parts of the film, leaving the bromide in the unexposed parts; the plate is then again exposed to light and developed. This method, proposed, I believe, by the late Mr. Sutton, is said to give very good results, but the use of nitric acid is an obvious disadvantage.

(6.) By copying in the camera, first making a transmitted positive either by the collodion process or with a special pigmented gelatine tissue. This method is most useful when the reversed negative is required to be either larger or smaller than the original.

(7.) By means of the reversing action of the red and blue rays of the spectrum. This method is a discovery of my own and has not yet been thoroughly worked out; it is, however, simple and could, I believe, be successfully utilised. A film of collodio-bromide of silver stained with anilin blue is exposed to light for a few moments, then placed under a negative in a printing frame in front of which is a sheet of red glass, and exposed to light. The action of the light passing through the red glass in the clear part of the negative is to neutralise or destroy the effect of the previous exposure of the plate to light, and on development a more or less perfect reversed

negative image is obtained. For line subjects a blue glass may also be used, but for half-tone work only a red glass can be employed.

In some processes also, it is convenient to use either direct or reversed transparent positives instead of negatives. These can be obtained either by contact printing on dry collodion plates or gelatine tissue, or in the camera, in the manner adopted for making transparencies, as described in the text-books.

Having now described the preliminary operations for preparing the original and producing the negative, which are common to all processes, we may proceed to the consideration of the different printing processes which, as stated in the introduction, may be divided into 6 classes, *viz.* :

I. Printing on sensitive papers. II. Photo-lithography or Photo-zincography. III. Photo-collotype. IV. Woodbury-type. V. Heliography or Photo-engraving. VI. Photo-typography.

IV. Photographic Printing on Sensitive Papers.

The processes under this head may be divided into three classes—

First :—Those in which the sensitive papers are prepared with salts of silver and the results are not permanent.

Secondly :—Those in which the sensitive papers are prepared with the salts of iron, platinum and other metals, and the prints though not absolutely permanent are more so than silver prints.

Thirdly :—Those in which coloured gelatine or other colloid mixed with an alkaline bichromate forms the sensitive surface and yields prints which, for all practical purposes, may be considered perfectly permanent.

Silver-printing.—Notwithstanding its expensiveness and the want of permanence of the prints, silver printing has hitherto maintained the first place among photographic printing processes, and though very nearly equalled, is as yet unsurpassed for the beauty and delicacy of its results. It is the process in most extensive use for producing copies of portraits and views, and although rapid advances are being made in more permanent methods, it is likely to be a long time before the beautiful but perishable silver print is entirely superseded.

The following brief outline of the operations will be sufficient to show the nature of the process.*

A sheet of paper coated with albumen containing an alkaline chloride, such as common salt, or paper which has merely been immersed in a solution of such salt and dried, is floated on a solution of nitrate of silver and allowed to dry in the dark. It is then placed above the negative in a copying frame, which is so constructed that the light may pass freely through the negative, and at the same time may admit of the examination

* For details, see Abney's *Instruction in Photography*, p. 113.

of the print while the back surface of the sensitive paper is shielded from light. The exposure to light lasts for some minutes, by which the parts unprotected by the denser parts of the negative are darkened more or less, according to its translucency, while the parts entirely shielded from the light remain quite white. When the action of the light is judged sufficient, the sensitive paper is removed from the frame in a dark place, and must then undergo an operation of *fixing* to remove the unchanged salts of silver, which would cause the print to darken unless carefully protected from the light. This is effected by steeping the print for a short time in a solution of hyposulphite of soda; but before the print undergoes this indispensable operation it is usual to place it in a solution of chloride of gold, by which part of the reduced silver forming the image is replaced by a film of gold and the print takes a more agreeable tone, also becoming more permanent than it would be if this operation, called 'toning,' were omitted. It is, however, impossible to ensure perfect permanency of these prints, by reason of the sulphur contained in the albumen or in traces of sulphur salts formed by the decomposition of the hyposulphite of soda, and left in the print after even the most careful washing, slowly acting on the reduced silver forming the image and converting it into a sulphide, by which the tone and brilliancy of the picture are lost, and the lighter shades appear to fade away entirely. It should, however, be stated that prints prepared on plain, or unalbumenised, paper are more permanent than the albumenised prints, though not so brilliant, sharp and delicate; and they have the further advantage of being less liable to shrinkage and distortion than the albumenised prints, and are thus more suitable for the reproduction of maps where accuracy of scale is a desideratum.

It is evident that owing to the expensiveness of the materials used in producing these prints and their want of permanency, together with the slow rate at which they can be produced, this process is almost useless for the reproduction of maps in large numbers; and, in fact, its use in cartography is limited to making copies of special maps for immediate reference or temporary purposes, and as guides for engravers or lithographers in preparing compilations from maps on a larger scale. Silver prints have also been used by engravers to obtain a correct tracing on the waxed surface of their copper plates, but unless these prints are prepared with great care they are open to the objection of becoming distorted and untrue to scale by the contractions and expansions caused by the successive washings they have to undergo. Prints on plain paper are better for this purpose than those on albumenised paper, and prints on paper containing a large proportion of resin in the size are better still.

In the English Ordnance Survey the topographers are furnished with silver-print reductions from the large scale outline survey, on which

they insert the features of the ground, suitably delineated according to the scale.

A very early application of this process has lately been re-introduced in Germany by Herr Romain Talbot, of Berlin, under the title of the *Lichtpaus* process, with the object of enabling engineers and others to readily prepare a few copies of their plans without the necessity of using a camera and other expensive appliances. In this method a print on a sensitive chlorised paper, prepared with nitrate of silver and an organic acid, so that it may be kept for some time in stock ready for use, is first taken by exposing it to light under the original drawing itself, which to secure the best results should be drawn in very black ink on thin paper or vellum cloth. This print, on which the lines are clear and the ground opaque, is simply fixed in a solution of hyposulphite of soda and then thoroughly washed and dried. A second copy is now made from this negative print in exactly the same way, and as, this time, the lines darken under the clear parts of the negative and the ground remains clear, we obtain a perfect transcript of the original. This process is said to be largely used in Germany for copying maps and engineering plans. It is no doubt useful in many cases where it is undesirable or impossible to make more extensive photographic arrangements, but besides being limited to the reproduction of copies on the same scale as the original, it labours under the disadvantages of expense and want of permanency common to all the silver printing processes.

In the processes just noticed the exposure to light is usually from 15 to 30 minutes, but in dull weather, or with certain negatives, it may be much longer ; it is obvious, therefore, that even under the most favourable conditions comparatively few prints can be produced from a single negative in a day. In order to shorten the exposure and permit prints to be produced with much greater rapidity than with the ordinary process, a method has been introduced by Major Libois of the Belgian army, by which, instead of the image being produced at once in its full strength by the action of light, the latter is only allowed to act for a few seconds, and the full effect is produced by treating the print with a developing agent composed principally of gallic acid, which at once reduces the silver in the parts acted on by the light, and thus produces a visible image in place of the almost invisible one formed by the action of the light alone. This process was extensively used in the Depôt de la Guerre, Paris, some years ago, and large numbers of maps were turned out by it, I was told, almost as quickly as they could have been printed in the press, and it had the further advantage that facsimile copies could be made of maps from which good results could not have been obtained by photolithography. The same process was used at the Depôt de la Guerre in Brussels, but not on so large a scale. I have also used it with success in India, and it may be recommended in

cases where silver printing is required for maps &c. It is more economical than the ordinary process, and much more rapid in working, the exposure being counted by seconds instead of by minutes. The operations are briefly as follows:

Thin photographic paper is salted by floating on a solution containing 2 per cent each of chloride of ammonium and citrate of soda in water slightly acidified with citric acid. The paper is dried and may be kept for use. It is sensitised by floating in the dark on a bath containing 5 per cent of nitrate of silver acidified with a little citric acid. The exposure to light is conducted in the same way as in the ordinary process, but is exceedingly short—a few seconds to one minute being generally sufficient. When taken from the printing frame only a very feeble image is visible, it is therefore developed in a mixture of a solution of gallic acid (1 to 3800 water) with a solution of acetate of lead (1 to 200 water), to which a little acetic acid is added. The detail gradually strengthens, and in about a quarter of an hour the prints are fully developed and of a good black colour. After being washed they are fixed in a bath of hyposulphite of soda at 30 per cent., then well washed and dried.*

The foregoing are the principal methods of silver printing suitable for cartographic purposes, but, however convenient and useful they may be for special objects where photolithography is not applicable, they cannot be considered adapted for purposes of publication, and their want of permanency is an insuperable defect.

Printing with Salts of Iron.—From time to time attention has been drawn to the possibility of replacing silver-printing by processes depending on the use of the salts of iron and other cheap materials, but, though certainly useful in some respects, they have never been brought into extensive practical use.

One of the best known of these processes is the 'cyanotype', invented by Sir John Herschel, and lately re-introduced by Messrs. Marion & Co., of Paris, who prepare and supply the ferro-prussiate paper ready for use. Good even-textured paper is brushed over with a mixture containing nearly equal proportions of 10 or 12 per cent solutions of ammonio-citrate of iron and the ferridcyanide of potassium, dried and exposed to light under a print or drawing placed with the printed side uppermost. The resulting faint photographic image is developed and fixed by a mere washing in plain water, yielding a print in white or light blue lines on a dark blue ground.

This process is rapid, simple and cheap. The camera is dispensed with, and the only photographic apparatus required is a printing frame and

* Maës and Hannot's *Traité de Topographie et de Reproduction des Cartes au moyen de la Photographie*, p. 295.

one or two dishes or trays. The sensitive paper is easily prepared and can be kept indefinitely in the dark until required for use. There is no messing with chemicals after the preparation of the paper, pure water only being required to develope and fix the prints. The exposure to the light is very short, two or three minutes in the sun being ample to make a clear legible copy from a line negative or from a drawing on tracing cloth. The chemicals employed are both very inexpensive.

The objections to the process are two: first the difficulty of obtaining clear whites; this, however, is of no consequence so long as the details are clearly legible; and secondly, the colour of the prints—white on a dark blue ground. Although this does not interfere with the practical use of the process for special work, it completely prevents it from being employed as a means of multiplying copies of maps or plans on a large scale. Another defect is, the want of sharpness arising from the necessity for placing the reverse side of the original in contact with the sensitive paper in order to get an unreversed print. These objections may be partly obviated by printing from a negative on paper or glass, in which case the lines will be dark blue on a light blue or white ground, but then cameras and other expensive photographic apparatus will be required to produce the negative.

M. H. Pellet has recently recommended a process of this kind whereby prints are obtained in dark lines on a clear ground. Paper is sensitised in a mixture of—

Oxalic acid,	...	...	... 5 parts
Perchloride of Iron,	...	...	... 10 „
Water,	...	...	... 100 „

dried and exposed as usual under a drawing. The print is developed in a bath of yellow prussiate of potash at 15 or 18 per cent, well washed and fixed with dilute muriatic acid, then finally washed and dried.

The blue prints thus produced can also be used as the basis of drawings for photozincography.

Another process, which, though not quite so simple as the above, has the advantage of giving a print in black on a white ground, forms one of the numerous important photographic methods for which we are indebted to the illustrious Poitevin.

Paper is coated in the dark with a solution of perchloride of iron and tartaric acid in water; when dry, it is exposed under a tracing on cloth or paper, or a reversed positive on glass, and as soon as the parts exposed to the light have become thoroughly bleached the print is removed and developed in a bath of gallic acid. The parts protected from the light turn to an inky black, while the exposed and bleached parts remain white or only take a slight tint. The print is then thoroughly washed and dried. The whole

operations of printing, developing and washing can be finished in half an hour. This process, simple as it appears, requires certain precautions in using a strongly sized paper for the prints, and a very transparent original to obtain the most successful results.

It is capable of the same applications as the cyanotype last described, and, like it, is quite unsuitable for producing maps for publication.

Another process of Poitevin's is dependent on the property possessed by the ferric salts of rendering gelatine insoluble, the solubility being, however, restored when the ferric salt is decomposed by the action of light into the ferrous salt.

Paper is thinly coated with a 6 per cent solution of coloured gelatine and when dry immersed in a solution of—

Perchloride of Iron,	10	parts	or*	1 to 3	parts.
Tartaric acid,	3	„	„	⅓ to 1	„
Water,	100	„	„	100	„

and dried in the dark. After exposure to light under a positive, such as a map on tracing paper, the print is immersed in hot water, and the gelatine in the parts exposed to light dissolves out, leaving an exact transcript of the original drawing with dark lines on a white ground. The print may be rinsed in water acidulated with hydrochloric acid to remove the iron salt.

Salmon and Garnier have taken advantage of the fact that if paper is coated with a solution of the percitrate of iron and exposed to the light, the parts exposed to the light become hygroscopic in inverse proportion to the intensity of the action of light, and therefore if such paper is exposed to light under a map or drawing on thin paper or vellum cloth, and afterwards brushed over with a fine powder, such as lamp-black or plumbago, more or less of the powder will adhere to the parts protected from the light, while the exposed parts will scarcely take it at all. After development the print has only to be washed to remove the unaltered iron salt from the film.

Other similar processes of printing with the salts of iron, uranium &c., will be found in the text-books. They are, however, very little used and may be regarded more as curiosities than as practical printing methods.

Platinum printing process.—There is, however, one process which deserves mention as producing very beautiful and permanent prints, in which the image is formed of reduced platinum. This process has been patented by the inventor, Mr. W. Willis, junior. Paper is floated on a weak solution of nitrate of silver and dried. It is then brushed over with a solution of double oxalate of potassium and iron, together with a solution of chloroplatinite of potassium. After exposure under a negative the print is floated on a warm solution of oxalate of potash, which causes the platinum

* Boivin, in *Moniteur de la Photographie*, 1st April, 1878.

salt to be reduced in the parts exposed to the light. The prints are fixed first with hyposulphite of soda, and then with oxalate of potash and finally washed with water.

Collo-chromate printing.—We now come to the more important processes depending on the reaction of the salts of chromium, particularly the alkaline bichromates, on gelatine, gum, albumen and other colloid substances under the influence of light, whereby these substances become more or less insoluble in and unabsorbent of water in proportion to the amount of the action of light, and further acquire the property of taking up greasy ink and not attracting plumbago or other fine dry powder, also in proportion to the amount of the action of light upon them.

This simple reaction, only partially discovered in 1839 by Mungo Ponton, was first worked out and turned to practical account, some twelve years afterwards, by Fox Talbot in his process of photoglyphic engraving; and after him Pretsch and, notably, Poitevin employed it in processes which have been the foundation of nearly all the modern methods of permanent photographic printing.

The simplest of all these processes, and one which may render useful service in the cases already noticed where only a few copies are required, was one of the first published by Poitevin. It consists in coating paper with a mixture of albumen, gum, or gelatine and bichromate of potash, coloured with Indian ink or any other suitable pigment; or, if preferred, the paper may be coated with coloured gelatine and then made sensitive in a separate bath of bichromate of potash, and this is sometimes the best method, because the paper will not keep good for long in its sensitive state. The sensitive coloured paper is exposed under a very clear line negative in a copying frame for a few minutes, and then taken out and plunged into water, either hot or cold, according as gelatine, gum or albumen have been used. The unaltered colloid in the lights of the print, which have been protected from the light under the dark parts of the negative, dissolves in the water, leaving a clear image in pigment on a white ground.

This simple method is capable of extensive use in copying maps or topographical sketches, but is only applicable to subjects in line, well drawn in black and white in accordance with the rules in Sect. III. These prints have the advantage of being quite permanent and, as the collo-chromate mixture is more sensitive to light than the chloride of silver, they can be produced at a quicker rate than the silver prints, and are, of course, cheaper on account of the inexpensiveness of the materials used.

For reproducing subjects in half tones a different procedure must be followed. In the process just described the exposure to light and the development of the print by washing are effected on the coloured side of the paper, and as the light can act with full power through the clear spaces on

the negative, representing the lines of the subject, it renders the colloid coating insoluble throughout the thickness of the coloured film, so that the lines withstand the solvent action of the warm water, which entirely removes the rest of the coloured film from the ground and parts which have not been influenced at all by the light. If, however, instead of a negative of a line subject, on which the lines are transparent and the ground opaque, we take a negative of a subject in half tones, possessing various degrees of translucency in the lights and shadows of the picture, and make a print from it on a piece of the pigmented paper, we shall find that the light will only be able to penetrate through the entire thickness of the colloid film in the deepest shadows, represented, as before, by nearly clear glass; in the darker half-tones it will penetrate nearly through the coating; in the middle tones about half-way through, and in the lightest tones the light will be able to act only on the surface of the gelatine. We shall therefore have a print with an insoluble surface of varying depth, and underlying this a more or less soluble layer; it will thus readily be understood that when exposed to the action of warm water this layer will dissolve and carry away with it the partially insoluble surface-film forming the half shades of the picture, leaving only the stronger shades and giving a rough, hard, and unfinished appearance to the print.

For a long time this difficulty proved a stumbling-block in the way of the progress of permanent printing and gave the silver-printing processes a supremacy of which it has now become difficult to deprive them. The Abbé Laborde was the first to see the necessity for adopting the principle of exposing on one side and developing on the other. Blair, Fargier and Swan applied this to the carbon process, and the latter finally succeeded in introducing a practical method of pigment-printing applicable to the same class of subjects as silver-printing. Swan prepared a tissue by coating paper with a thick layer of gelatine mixed with bichromate of potash and coloured with any suitable pigment. After the exposure to light the gelatinous surface of the tissue was caused to adhere closely to a second piece of paper coated with india-rubber. The whole being immersed in hot water, the paper on which the gelatinous layer was originally supported, became loosened and could be removed, allowing the hot water to gradually dissolve away the unaltered and soluble gelatine. In this manner the exposure to light takes place on one side of the gelatine film, while the washing away of the superfluous gelatine is effected from the other, or unexposed side, without disturbing in any way the exposed parts of the film, and thus the most delicate shades in the half tones are perfectly preserved. Since its introduction by Swan this process has been much improved by Messrs. J. R. Johnson, R. Sawyer and other members of the London Autotype Company which acquired Swan's patents, and under

the name of the 'Autotype' process, it has been worked on a large commercial scale for the reproduction of works of art, and is now fairly beginning to come into active competition with silver-printing for all ordinary purposes of portrait and landscape photography.

On the Continent, the pigment-printing process is largely used by the well-known houses of Braun and Goupil for the reproduction of works of art, and is also coming into extended use for general purposes.

The following is an outline of the operations as now practised by the Autotype Company.*

The pigment tissue is prepared by coating long bands of paper with a moderately thick layer of gelatine coloured with any suitable pigment, and is sold ready for use either in an insensitive or sensitive condition.

The tissue is sensitised by immersion for a minute or two in a 5 per cent solution of bichromate of potash in water, to which some alcohol may be added with advantage, especially in hot climates; the bath should also be cooled down with ice if its temperature exceeds 65°. The tissue is then carefully dried, and when dry is ready to be exposed under the negative. This is done in a printing-frame in the usual way, the only precaution necessary being to paste slips of thin grey paper round the edges of the negative, so as to cut off a great portion of the light and form what is called the 'safe edge'. As the tissue generally appears black all over, the progress of the printing cannot be ascertained by inspection, and it is necessary to use a little instrument called an 'actinometer', by means of which, the degree of exposure necessary for any negative having been once ascertained, it is easy to give the same amount of exposure to successive prints. Up to this point the operations are the same whatever may be the nature of the support upon which the picture finally rests. The subsequent operations, however, differ accordingly as the image is developed on a final support, by what is called the 'single transfer' method, or on a temporary support, by the 'double transfer' method. In any case, some support is indispensable to retain the image and preserve it from injury during the washing.

In the single transfer process the support is paper coated with a gelatinous substance which, though insoluble in water, retains sufficient adhesive power when moistened to enable it to hold the picture during development and afterwards permanently.

After exposure under the negative the pigmented tissue having been immersed in cold water, together with a piece of the transfer paper, the two surfaces are applied to one another under water, and both drawn out together. They are then laid on a zinc plate, tissue uppermost, and brought into close

* See "*The Autotype Process*", 6th edition. Also Monckhoven's, Vidal's and Liesegang's treatises on Carbon-printing.

contact, all intervening air being driven out by means of an india-rubber scraper, or 'squeegee', which also removes all superfluous moisture. The prints and support are allowed to remain together for a short time, and are then immersed in warm water. After a little while the soluble gelatine will soften and become partially dissolved, when the paper forming the original support of the layer of gelatine may be gently removed, leaving a dark slimy-looking mass on the transfer paper. The soluble gelatine gradually clears away by the action of the hot water and reveals the image in more or less perfection of details according as the exposure has been properly timed. When fully developed, the print is washed with cold water, then passed through a solution of alum, rinsed again with water and allowed to dry.

Instead of paper, any other suitable permanent support may be used, but whatever the support may be, a reversed negative must be used if it is desired to obtain non-inverted pictures by the single transfer method.

When it is inconvenient to use a reversed negative, and it is desired to obtain a non-inverted picture—the development of the tissue-prints must be conducted by the double transfer method upon a temporary support, either rigid or flexible. The discovery that the pigment pictures might be developed upon any impermeable surface is due to Mr. J. R. Johnson, who also found that if such surface previously receive a coating of some fatty or resinous compound, the picture may be transferred, after development, to a final support.

The most suitable surface for the temporary support is a sheet of zinc, which may be either polished or grained; opal glass, or porcelain plates may also be used with advantage.

The plate employed as the temporary support first receives a coating of a solution of wax and resin in turpentine, and some operators coat the plate with collodion after the waxing, in order to improve the surface. The pigment tissue carrying the image is attached to the support under water in much the same way as in the single transfer method, and after remaining for a time, is developed in the same way and allowed to dry. The plate with the picture on it is then rinsed in water, and a piece of what is called double transfer paper—a fine paper coated with an enamel surface—having been soaked in water till quite soft, is laid on the wet plate, avoiding air-bubbles, and pressed into perfect contact with it by means of the india-rubber scraper. The picture with the transfer paper attached is now dried carefully, and when dry separates of itself from the temporary support.

Mr. J. R. Sawyer of the Autotype Company has introduced a flexible support, consisting of paper coated with a solution of gelatine rendered insoluble with chrome alum. When dry this is coated again with an alkaline solution of shellac, dried and well rolled under powerful pressure—it is afterwards coated with a waxing compound. The use of this flexible sup-

port is said to be advantageous with small pictures, but I have not found it answer very well in this country.

All these operations, which seem so complicated, are in reality very simple, and as the sensitised tissue is very sensitive to light a great many prints can be produced in a single day. The number may, moreover, be increased by a plan proposed by Capt. Abney, R. E., of exposing the print for only half the usual time and then letting it lie by in the dark for some hours. The decomposing action set up by the light goes on in the darkness, and on development a picture is produced quite as good as if it had received a full amount of exposure and been developed at once. This discovery is largely utilised by those working the process in England, and enables an amount of work to be done in the winter months which would otherwise be impossible.

The single transfer process has been successfully worked at the Surveyor General's Office in Calcutta for the production of photographs of the convicts transported for life to the Andamans. No great difficulties were met with in working it, even in the hot weather, but it was found necessary to ice the solution of bichromate of potash used for sensitising the tissue, and to add a certain proportion of spirits of wine to it, in order to keep the gelatine from softening too much. Messrs. Bourne and Shepherd, the well-known Indian photographers, have made arrangements for working the Autotype process at Simla, the climate of Bombay having been found unsuitable.

The pigment prints are perfectly permanent for all practical purposes, and, though they may under certain circumstances change colour slightly or lose their brilliancy, there is no such absolute fading and loss of details as in silver prints. The process may be applied in all cases to replace silver printing where permanency of results is an object. As I have mentioned before, the process is not quite suitable for the reproduction of coloured or shaded maps, owing to difficulties in obtaining prints comprising large surfaces of clean white paper together with the delicate half tones of hill-shading. For maps in line the simple carbon process is more suitable, or if many copies are required, photozincography would be better.

Anilin Printing.—Before proceeding to the consideration of the processes employed for producing prints in the printing press, mention may be made of an ingenious process of printing which depends upon the use of salts of chromium, and is largely used in Europe for the reproduction of maps and plans. It is known as the 'Anilin printing process' and is the invention of Mr. J. Willis, who has patented it.

Paper is impregnated with a solution of bichromate of potash to which a little phosphoric acid has been added. After exposure to light under a transparent positive, such as a drawing on thin paper or vellum cloth, or even

an ordinary engraving or manuscript, it is exposed in a closed box to the vapour of anilin, which developes a greyish image. The print is then fixed by merely washing with water. As a positive original yields a positive print, maps or drawings may be copied without the necessity of making a negative by means of a camera, which is a great recommendation in certain cases. The process has hitherto been worked only by the inventor and his licensees and has not come into general use.

V. Photolithography and Photozincography.

In all the processes noticed in the last section, it is necessary to repeat the printing operation by exposure to light for every print produced. The rate of printing will consequently be more or less dependent on the sensitiveness of the paper, the strength of the light at the time of exposure and the state of the weather; the printing operations can, moreover, only be carried on during the few hours of daylight. In the photo-mechanical processes, now about to be described, these grave disadvantages are obviated, and, once the photographic image has been produced upon the printing surface, prints may be made in any numbers, quite independently of light or weather.

The simplest and most generally useful of these mechanical processes is photolithography, or the analogous photozincography, the principal difference between the latter and the former being merely the substitution of a thin smooth plate of grained zinc for the thick heavy lithographic stone. For maps of large size, zinc is certainly the most suitable and offers in other respects all the advantages of stone, but the latter being better known is generally preferred for ordinary work of moderate size.

In ordinary lithography, the image may be produced on the stone or zinc either by *transfer* from a drawing on paper with the solution of resinous soap known as 'autographic ink', or by *drawing direct* on the stone with a similar ink or crayon; so in photolithography there are two similar methods of obtaining the photographic image—either by transfer from a photographic print in fatty ink—or by impressing the image direct on the stone, by applying a photographic negative on a suitable coating sensitive to light and removing by means of a solvent the parts unaltered by light. The transfer method being the most convenient is the one in general use.

The first photolithographic process on record is that proposed by Jobard, of Brussels, who, in 1839, obtained lithographic proofs from stone or zinc plates that had been treated with iodine or bromine. This process never came into practical use and has been quite superseded by two distinct methods—one dependent on the alterability of asphaltum under the influence of light—the other on the reactions of the alkaline bichromates upon gelatine and other colloid substances.

Asphaltum methods.—In 1852, MM. Lemercier, Lerebours, Barreswil and Davanne, proposed a method of litho-photography, in which a stone was coated with a solution of bitumen in ether, exposed to light under a reversed negative, and developed with ether, which dissolves the parts not affected by the light, while the exposed parts being insoluble remain and form the image. (Benzole, chloroform or turpentine may also be used instead of ether). After development the stone was prepared with acid and gum and inked in the same way as an ordinary lithographic drawing.*

Since then many other similar asphaltum processes have been proposed and have been worked with great success, both for subjects in line and half-tone; but, owing to the length of exposure required and the uncertainty of the results, this process is not well adapted for general use, and has, I believe, been almost abandoned in favour of the collochromate methods.

Collo-chromate Processes.—Paul Pretsch, whilst working out his photo-galvanographic process, hereafter to be described, discovered that if a mixture of gelatine and bichromate of potash be spread upon a suitable support and when dry exposed to light, then again moistened and inked in with a roller charged with printing ink, the ink would only take upon the parts altered by the light, and thus impressions could be obtained by transferring the design to zinc or stone.

Pretsch does not seem to have made any practical use of this discovery, but shortly afterwards, in 1855, Poitevin independently worked out a photolithographic process on the same principle, which has been the foundation of all the present processes of photolithography and photocollotype and is worked to the present day for the reproduction of the Belgian topographical maps. Poitevin impressed his photographic image direct upon the stone and not by transfer.

The first practical *transfer* process of photolithography seems to have been suggested by Asser, of Amsterdam, early in 1859. He coated unsized paper with starch, and then floated it on a strong solution of bichromate of potash. When dry it was exposed to light under a well intensified negative. The print was next heated with a flat iron, then moistened and inked in with transfer ink, by means of a roller, and thus an impression was obtained which could be transferred to stone or zinc.†

The next transfer processes were the Southampton process of photo-zincography, which was founded on Asser's, and Mr. Osborne's process of photolithography. These two processes, though quite independent one of the other, were identical in principle and almost so in details; the only difference being that Mr. Osborne added a certain proportion of albumen to the mixture of gelatine and bichromate and then treated his prints with boiling water, in

* See Davanne, *Chimie Photographique*, p. 456.

† *Photographic News*, Vol. III, p. 146.

order to congulate the albumen and leave a slight coating of it on the paper, so as to obtain a 'grip' on the stone during the process of transfer.*

At the Ordnance Survey Office, Southampton, and at the various photographic offices in India, in which the process has been introduced from Southampton, photozincography is used, with the best results; but in Australia, America and the Continent of Europe photolithography is more usual and it is also used at Madras.

These processes have occasionally been used with fair success for the reproduction of shaded maps, architectural views and other subjects in half-tones, but they are not by any means suitable for such subjects, and are best adapted for the reproduction of maps and drawings boldly executed in dot or line alone.

They may also be used for copying prints or engravings of all kinds on the same, larger or smaller scales, but engravings, and even many lithographs, are generally more or less unsuitable for the purpose. The best results are obtained from original drawings specially prepared to suit the requirements of photographic reproduction, in strict accordance with the rules already given.

The following outline of the Southampton method will give an idea of the operations. Like the pigment-printing process, already described, it depends upon the property possessed by a dried layer of gelatine and other colloids, when mixed with an alkaline bichromate, of becoming insoluble and repellent of water under the influence of light. The procedure, too, is much the same as in the simple pigment-printing process, except that, instead of the fatty ink which forms the image on the photo-transfer print being mixed with the gelatine, it is applied to the surface of the print after exposure to light. The inked print is then washed in hot water, by which the colloid coating in the unexposed parts is dissolved and carries away with it the superfluous ink not retained by the lines forming the image.

The negatives are obtained by the methods already described applicable to the reproduction of subjects in line.

Having obtained a suitable negative, the next operation is to produce from it a photograph in greasy ink which may be transferred to zinc or stone.

To prepare the sensitive paper, a sheet of bank-post paper is coated twice with a mixture of 6 parts gelatine and 4 parts bichromate of potash, dissolved in 100 parts of water, dried in the dark and glazed to give it a smooth surface. It is then exposed to the light under a negative for one or two minutes in the sun, or until the finest lines are distinctly visible. When sufficiently exposed, which may be ascertained by the whole of the detail appearing in brown upon a bright yellow ground, the print is taken out of

* *Photographic News*, Vol. IV, p. 374.

the printing frame and passed through a lithographic press in contact with a polished stone, or zinc plate, which has been coated with a lithographic transfer ink, and thus receives an even coat of the greasy ink. The inked print is immersed for a few minutes in tepid water, to soften the gelatine still remaining soluble in the parts not acted on by light, and then laid on a sloping glass or metal plate and gently washed with a sponge and warm water till all the unaltered gelatine is removed, carrying the superfluous ink with it. The lines, on which the light has acted, remain insoluble and retain the ink, forming a clear image of the subject in a greasy transfer ink, precisely similar to the ordinary lithographic transfer drawing. When all the details are clearly and sharply defined, and the ground is quite free from ink, the print is rinsed in clean water and dried. It is then ready for transfer to stone or zinc.

It often happens that a map is too large to be photographed in a single section. In this case the transfer prints of the different negatives are carefully joined together with gelatine and transferred to the stone or plate; or if too large to be printed in one sheet, the joined-up transfers may be cut up into as many convenient-sized sections as may be necessary.

Zinc plates possess great advantages over lithographic stones on account of their superior lightness, cheapness, facility for storage and less liability to breakage, and are therefore to be preferred in reproducing plans of large size. For fine work stone is considered by some to give better results than zinc, but I believe that if due care be taken as good prints may be made from zinc as the best from stone.

The plates used for this purpose are about $\frac{3}{16}$ of an inch in thickness, and have one side carefully planed and smoothed; but in order to give a somewhat porous surface to the plate, so that it may be more absorbent of moisture and hold the greasy ink better, the planed side of the plate is grained, or roughened by grinding it evenly all over with very fine sand and water. After the transfers are made, the plate is etched with a preparation of gum and decoction of gall-nuts to which a little phosphoric acid is added.

If the transfers are made to a lithographic stone instead of to a zinc plate, the operations are exactly the same as for transferring an ordinary lithographic transfer-drawing, except that the stone need not be heated. The operations of printing, whether from zinc or from stone, are precisely the same as in ordinary lithography.

Various modifications have been introduced, but the above process is still one of the best and most simple, and, if care be taken with suitable subjects, results may be obtained by it not to be surpassed by any other method. Full details regarding it will be found in Sir H. James' '*Photozincography*,' also in the *Photographic News*, Vol. XII, page

280 *et seq.* The accompanying specimen of a reduction from an old engraved map will give an idea of the results that may be obtained.

In the Southampton process the whole of the unaltered gelatine is removed from the paper, and the objection has been made that, in consequence of this, the ink on the lines being left on ridges of gelatine is more liable to spread in transferring, that the fine lines are liable to be washed away by the dissolution of the gelatine beneath them, and that the prints are liable to slip during transfer. To remedy these defects various methods have been proposed for retaining the gelatine on the paper.

One of the best of these methods has been perfected by Capt. Abney, who has patented it under the name of 'papyrotype.'*

A tough paper is coated with gelatine, and subsequently treated with alum or chrome alum. It then receives a coating of gelatine and bichromate of potash as in the Southampton process. After exposure to light the print is drawn through *cold* water, and is then 'squeegeed' down on to a smooth metal plate, and inked in with a soft gelatine roller charged with transfer ink. The ink 'takes' only on the parts exposed to light, while the ground of the print remains clear. When the image is fully inked up, the print is dried and exposed to light, to harden the gelatine thoroughly by the action of light on the bichromate salt still remaining, and is then ready for transfer to stone or zinc.

Among the advantages claimed for this process, the principal are that—

The ink which forms the lines is not left on ridges of gelatine, as in the Southampton method. The fine lines are not liable to be removed. The surface of the transfer will have no tendency to slip during transfer.

In practice this method was not found to answer in this country so well as the ordinary one, but a modification of the latter has lately been introduced in the Surveyor General's Office, with the same object as the papyrotype, and seems to answer well.

The paper is prepared as usual with two coats of gelatine and bichromate of potash. It is then put away for a few days, in order to allow the gelatine to become hard and insoluble. When required for use, it is coated again with a mixture of gelatine and bichromate of potash of about one-third the usual strength, and is then exposed to light and inked in the usual way. The washing is done with cold water instead of with hot.

Instead of allowing the gelatine to harden by keeping, which takes from 8 to 12 or 14 days according to the season, the hardening action may be hastened by laying the sensitive paper face downwards on a board, and allowing the light to act on the back surface for a minute or two. This may be done, either after the print has been obtained from the negative, or just

* '*Instruction in Photography*,' p. 155.

after the preliminary coating has been given to the paper. The gelatine may also be hardened with alum or chrome alum.

It has been found that this method has the advantage that a base of hard insoluble gelatine remains on the paper and retains the finest lines, while the fresh and easily soluble final coating preserves the clearness of the ground. It is necessary that the underlying gelatine should be thoroughly hardened, otherwise the transfers stick to the zinc plate in transferring, and are difficult to remove ; the soft gelatine is also liable to spread over the lines and prevent their transfer.

Another advantage is that warm water is not required for washing the prints, and the ink is not so liable to become pasty as in the usual mode of working. The lines are found to keep crisp and the spaces between them free from scum, thus giving clearer and sharper transfers.

Mr. Herbert Deveril, Government photolithographer in New Zealand, found that, in working Osborne's original process of photolithography, which is still generally used in the Australian Colonies, great inconvenience arose from the use of boiling water to coagulate the albumen added by Mr. Osborne to the gelatine in order to produce an insoluble surface with a 'grip' on the stone. He has therefore substituted the following method of producing his transfer prints. Paper is first coated with gelatine to which a small proportion of chrome alum has been added. This is allowed to dry and is then sensitised in a solution of bichromate of potash. The prints are exposed and inked as in the Southampton process, and are washed off in cold water.* Mr. Deveril claims for this method the further advantage that the sensitive paper can be kept in good condition for a long time. The keeping properties of papers coated with gelatine and bichromate are, however, very dependent on climatic conditions. The results which I have seen by the process are exceedingly good.

A method of photolithography by transfer which yields excellent results in line, and even reproduces half-tones fairly well, is a modification of Asser's process, invented by Mr. Toovey, of Brussels, who coats paper with a solution of gum arabic mixed with bichromate of potash, and after exposure to light under the negative in the usual way, places the transfer-print face downwards on the stone with several thicknesses of wet blotting paper over it, and leaves it under pressure for some hours in a powerful press.

The gum on the parts not exposed to light being soluble is forced into the stone and prepares it, while the lines being hardened and rendered insoluble leave the stone quite free from gum and ready to take printing ink from a roller when passed over them, thus producing an image which may be printed from as soon as the soluble bichromate salt has been washed out, because the bichromated gum is a most powerful preparation for the stone

* '*Photographic News*,' Vol. XIX, p. 585.

and, indeed, is difficult to remove without grinding the stone down to some depth.

This process requires care in adjusting the amount of moisture to be applied to soften the gum, so that it may not be squeezed under the lines and block them up, and it has not, I believe, come into general use.

There are two disadvantages which militate against the employment of the transfer processes of photolithography for the finer and better class of maps. The first, is the difficulty of obtaining reproductions perfectly true to scale, owing to the unequal expansion of the transfer paper in the various washings and squeezings it has to undergo. Although this unequal expansion and contraction is very slight, and for most practical purposes may be disregarded, it has greatly hindered the more universal adoption of this valuable method for the reproduction of the official maps in England and foreign countries.

Mr. Rodriguez, of Lisbon, has, however, lately introduced an improvement into the transfer process with the object of doing away with the possibility of stretching in the course of any of the operations.* Instead of using paper as the support of the coating of gelatine on which the photographic image is impressed, he uses a sheet of tinfoil about the thickness of thin paper. This is first smoothed on a very finely grained lithographic stone and then laid down quite flat on a sheet of zinc. After being cleaned with alkali and well washed, the tinfoil is brushed over with a solution of gelatine and bichromate, dried rapidly, and is then ready to be exposed under a negative in the usual manner. To ink the print, the sheet of tin is first plunged into water, and then carefully laid down wet on a lithographic stone so as to avoid folds, the gelatine side being uppermost. The film is then inked in with a roller. After the first inking in the print is left for about a couple of hours and is then inked in again and afterwards washed with a sponge and water. It may then be lifted off the stone and dried. The operations of transfer are the same as usual.

The second disadvantage of the transfer methods is the almost unavoidable spreading of the lines under the operation of transferring, which makes a photolithographed map look heavy and unsightly compared with a lithographed one. This defect may, however, be diminished very much by skilful manipulation and taking care to have as thin a coating as possible of gelatine on the paper, and to use a good hard transfer ink in small quantity. With these precautions and with a suitable original, results may be obtained from photolithographic transfers which will well compare with ordinary lithography, or even engraving, in sharpness and delicacy.

These special defects of the transfer methods may be in great part obviated by impressing the photographic image direct on the stone, as origi-

* '*British Journal of Photography*,' Vol. XXV, p. 232.

nally proposed by Poitevin, but this plan has again other disadvantages of its own which render it less suitable for map work than the transfer process. It has, however, been used extensively, and very successfully, in the production of the Belgian topographical maps on the scale of 1 : 20,000.

In the process used for the Belgian maps, the stone is covered with a very thin coating of a mixture of gelatine and bichromate of potash, rapidly dried and exposed to light under a reversed negative, which is obtained by reversing the position of a dry tannin plate in the camera and allowing the light to act through the glass on the underside of the collodion film. A thin coating of printing ink is then applied all over the stone with a roller, and the surface is afterwards washed with warm water in which a little starch has been dissolved. This gradually removes all the soluble parts of the gelatine coating, leaving on the stone a clear image of the map. The stone is then covered with gum and after drying and remaining for a short time is ready for printing and capable of yielding 1500 good impressions.*

For line-work zinc plates are also used and prepared in much the same way.

This process has undoubtedly some advantages as regards accuracy of scale, and the quickness and cheapness of the operations, but on the other hand it has disadvantages as regards the difficulty of securing perfect contact between the stone and the negatives, the necessity for a reversed negative, the prints being limited within a single negative and the inconveniences of working with heavy stones.

Besides the foregoing, many methods of photolithography have been proposed, but as for the most part they are only modifications of the processes I have described, which are all good and may be considered typical, it will be unnecessary for me to go further into details regarding them.

VI. Photocollotype.

The great defect of all the processes of photolithography described in the last section is, that they can only be applied with advantage to the reproduction of drawings or subjects in which the gradation of shade is shown by lines or dots separated by white spaces of varying sizes and at different intervals apart, as in line or stipple engravings and lithographs in line or chalk. Even such drawings to be successfully reproduced must be in a good bold open style and have all the lines or points composing them of an equal and perfect blackness. In the many attempts that have been made to reproduce photographs from nature by photolithography or photo-engraving, or to copy paintings and brush-shaded drawings in which gradation of shade is continuous, success, only partial at best, has been secured by

* Maës and Hannot's '*Traité de Topographie, et de Reproduction des Cartes au moyen de la Photographie*'; also Hannot's '*La Photographie dans les Armées.*'

breaking up and destroying the continuity of gradation. By the processes of photocollotype, so called from the printing surface being of gelatine, these defects are entirely obviated, and absolutely permanent photographic prints may be produced in the printing press equal to silver prints in perfect delineation of detail and delicate gradation of shade, but vastly superior to them in permanence and cheapness of production.

Poitevin was the first to recognise, so early as 1855, the fact that the half-tones were better preserved on stones that had been treated with a chromated colloid mixture if, after exposure to light under a negative, instead of being inked all over and then washed with water to remove the superfluous ink, they were first moistened and then inked in with a lithographic roller charged with printing ink*. He seems, however, to have always regarded the stone as the principal printing surface and treated it by the ordinary methods of lithography. Only a few impressions could be obtained from stones thus treated.

In 1866, Messrs. Tessié du Mothay and Marechal, of Metz, discovered that the stone or metal plate hitherto used as a printing surface might be replaced by a mixture of isinglass, gelatine and gum, treated with an acid chromate, and evenly spread upon a well polished metal surface; because if, after exposure to light under a photographic negative, such a gelatinous surface were moistened, greasy ink applied upon it with a roller would adhere well to the parts of it that had been acted upon by light, and would be taken up by those parts in proportionate quantities, according to the intensity of the gradations of light and shade produced on them by the action of light, and their consequent impermeability to water. Photographic prints in fatty ink reproducing the most delicate gradations of shade without any apparent grain or break of continuity could thus be produced.†

It will be seen that this process was based on exactly the same principle as Poitevin's photolithography, but differed from it in the distinct recognition of the colloid film as the printing surface. Messrs. Tessié de Mothay and Marechal were also the first to recognise the necessity of adding a certain proportion of acid or of oxydising or reducing agents to the chromate salt used for sensitising the gelatine, with the object of rendering the colloid surface more apt to receive the greasy ink and also of hardening the film so as to enable it to withstand the wear and tear of printing. This they did by exposing the sensitive plates to a high temperature before using, but the effect was produced in great measure by the decomposition of the chromate salts by the acids or other substances added to the colloid mixture.

Messrs. Tessié du Mothay and Marechal printed off their 'phototype' plates in a lithographic press in much the same way as ordinary lithographs,

* '*Traité de l'impression photographique sans sels d'argent*,' p. 78.

† '*Photographic News*,' Vol. XI, p. 260.

but with certain modifications due to the peculiar nature of the printing surface. The principal of these was the use of two inks, one stiff, for giving force to the shadows, the other thin, for bringing out the more delicate half tones.

The 'phototype' process as at first proposed laboured under the defect of not being able to yield a large number of prints from a single plate, but, in 1869, it was improved upon in this respect by Albert, of Munich, who substituted a thick glass plate for the metal plate used by Tessié du Mothay and Marechal as a support for the colloid film. His films consisted of albumen, gelatine and bichromate of potash alone, and he gave them the required solidity and adherence to the glass by first coating the plate with a sensitive colloid mixture containing a large proportion of albumen, and then giving the under side of this first coating a preliminary exposure to light through the glass. The second coating containing more gelatine was then applied, and after it had dried, and the photographic image had been impressed upon it, the plate was again exposed from the back, in order to thoroughly solidify and combine the under part of the compound film. The gelatine films so prepared were capable of yielding some hundreds, or even, it is said, thousands of perfect copies. This process is still largely used by its inventor and is known by the name of Albert-type.*

According to some authorities, Messrs. Ohm, Grossmann and Gemoser, of Berlin, took out a patent, in 1867, for a method of photocollographic printing comprising, in addition to the use of glass as the support of the gelatine film, of the double coating of the plate and of the hardening of the film by exposure of the back surface, the introduction into the sensitive gelatine mixture of certain resinous compounds dissolved in spirit, by which the gelatine film is rendered quite insoluble and admirably adapted to form a fine printing surface. It is said on the other hand that the credit of all these improvements is due to Albert; but, in any case, it is certain that until after the publication of Albert's process early in 1869, Ohm and Grossmann's was almost unknown and had not come into general use. In October 1869, the Autotype Company in London acquired the patent, and have since worked the process with the greatest success.

About a year after the publication of Albert's method, Mr. Ernest Edwards, of London, introduced, under the name of 'Heliotype,' a very important modification of the photocollotype process.

He first waxed a glass plate and then coated it with a substantial layer of gelatine and bichromate of potash, containing a small quantity of chrome alum, with the object of hardening the gelatine and rendering it insoluble, without destroying its impermeability to water. When dry, the gelatine

* '*Photographic News*,' Vol. XIII, p. 121.

film was removed from the waxed glass plate, and the side which had been next to the glass was exposed under a reversed negative in the usual way, and, then, as in Albert's process, the back surface of the film was hardened by exposure to light. After this, the film was attached under water to a metal plate, preferably pewter, coated with india-rubber, and 'squeegeed' into perfect contact with it. The bichromate salt was then removed by washing and the plate was ready to be printed in an ordinary Albion printing press.

In this process the peculiarities were the use of chrome alum for hardening the gelatine ; the separation of the colloid film from its original support, by which perfect contact with the negative was secured, as well as less risk of breakage of the latter ; the subsequent transference of the film to a metal plate, by which the liability to breakage of glass plates in the progress of printing was obviated, and, lastly, the substitution of vertical instead of a scraping pressure in printing, by which the gelatine films were not exposed to injury by wear and scraping of the surface.

This process is still, I believe, largely practised and full details of it, with various improvements suggested by Capt Abney, R. E., will be found in the latter's excellent little work—"*Instruction in Photography.*"

About the same time, Herr Obernetter, of Munich, proposed another process of the same kind offering some peculiarities, and said to produce very satisfactory results.

A sheet of glass is coated with a mixture of gelatine, albumen, sugar and bichromate of potash, dried and exposed to light under a negative. The plate is then dusted over with finely powdered zinc, which attaches itself only to the parts protected from the light and in proportion to the amount of protection they have received. The plate is then heated to about 369° F., or exposed to light till the whole surface of the film has been rendered insoluble. Before printing, the plates are treated with dilute muriatic or sulphuric acid. By this operation the parts of the gelatine film covered with zinc, are rendered, by the formation of hydrogen, susceptible of attracting water to a greater or less degree, while the other portions, upon which no zinc has settled, are capable of receiving a fatty ink. The printing is then proceeded with in the usual manner.*

Since 1869, when these processes first began to come into practical use, many methods of working have been introduced, chiefly in Germany and France, but so far as known they are nearly all of them more or less modifications of one or other of the above, merely differing in the manner of preparing and hardening the gelatine film. A good deal of information on the subject will be found in Husnik's "*Gesammtgebiet des Lichtdrucks,*" Geymet's "*Phototypie,*" Moock's "*Traité pratique d'impressions photo-*

* '*Photographic News,*' Vol. XIII, p. 483.

graphiques aux encres grasses," and A. Martin's "*Handbuch der Email-photographie und der Phototypie oder des Lichtdruckes.*"

The great difference between the photocollotype processes and lithography is, that whereas the lithographic stone receives a like quantity of ink in all parts of the image, and is incapable of producing a true and continuous gradation of shade, the moist gelatine film possesses the valuable property, not possessed by the stone, of receiving a greater or less amount of ink in different parts of the image, in exact proportion to the intensity of the action of the light upon them, and is thus capable of reproducing the most delicate gradations of shade as perfectly as they are shown in an ordinary silver print.

It will thus be readily understood that instead of the advantages of photographic reproduction by cheap and speedy mechanical processes being confined to the reproduction of certain special subjects, they can be extended to all classes of subjects, such as photographs from nature, brush-shaded and coloured maps, MS. records, drawings and paintings of all kinds. Even for line subjects, the process surpasses most of the known processes of photo-engraving, photozincography or photolithography in the delicacy, sharpness and clearness with which the finest lines can be reproduced, as well as in perfect accuracy of scale, owing to there being no intermediate process of transfer, with its attendant washings and pressings, and the plate being printed by vertical pressure.

The process has the further advantage that the prints do not require mounting, and this makes it very suitable for book illustration, for which, indeed, it is now being very largely used. It is especially valuable for illustrations of a scientific character in cases where otherwise only the highest class of lithography or engraving would be applicable and at an enormously increased expense.

For the most successful application of the photocollotype processes to the reproduction of maps, the result depends, as in photozincography, very much on the quality of the negative, and that again on the original.

Any negative that will give a good photographic print will answer, but the successful reproduction of shaded maps or drawings demands considerable care in the execution of the original drawing as well as in taking the negative. The precautions to be taken in these respects have already been indicated in sections II and III.

For some years past my attention has been given to the utilisation of this valuable process for the reproduction of maps and other photographic work which the Surveyor General's Office is called upon to do for various Government departments. In the Proceedings of the Society for November 1871, I described a process which I had found to answer well for line work, and strenuous efforts were made to bring this and other methods into prac-

tical working. It is much to be regretted that owing to the many difficulties met with in manipulating the gelatine films in the hot damp climate of Calcutta, and in getting printers with the special artistic skill required to produce the best results, our efforts have not been quite successful, and, as photozincography is found more convenient for most of the work passing through the office, the photocollotype process has not been brought into general use.

As the process previously described in the Proceedings has since then been modified and is, I know, exceedingly good for line work, the following description of the manipulations, extracted from the Annual Reports of the Surveyor General's Office for 1871-72 and 1872-73, may prove of interest, especially as the working details of few of the other processes have been published.

The printing plates are of plate glass, about ⅛ or half an inch in thickness, evenly ground on one side with fine sand. When required for use they are thoroughly cleaned to remove all grease, and then carefully levelled.

The composition of the gelatine coating is as follows :—

A.	Gelatine,	1 ounce.
	Glycerine,	1 dram.
	Distilled water,	6 ounces.
B.	Albumen,*	1 ounce.
	Distilled water,	1 ounce.
C.	Tannin,	10 grains.
	Water, (in hot weather, Spirits of wine,)	1 ounce.

The above quantity will be sufficient for two square feet of plate.

As soon as the gelatine in solution A is quite dissolved, B is added and then C is poured in gradually with constant stirring. The whole is strained through two thicknesses of cotton cloth and poured evenly over the plates on the ground side, any air bubbles being carefully removed. The plates are then covered over with a light paper cover, to prevent dust falling on them, until they are *set*, when they may be removed into the open air and turned face downwards to dry. Or they may be dried with gentle heat in a drying box, but too quick drying is to be avoided because the gelatine films will dry unevenly.

When the plates are dry, they may be put away till required or sensitised in a bath of—

Bichromate of Potash,	1 part.
Water,	20 parts.

They are allowed to remain in this for 5 minutes, then removed to a drying box and dried with a gentle heat. When dry, the deposit at the back of the plates, and any inequalities at the corners of the gelatine film are

* 30 grains of carbolic soap may be used instead of the albumen.

removed, and the plates are ready for exposure under the negative, which must be a reversed one obtained as described in section III.

If the reversed negative has been taken direct on glass, the exposure to light is performed in a pressure frame, in the same way as for ordinary photographs. It is advisable, however, to secure clean margins by shielding the borders of the negative by means of a mask, cut out in yellow or brown paper, which should well overlap the edges of the printing plates. The sensitive plate may be rubbed over with a little powdered soapstone to prevent any adherence to the negative. Some sheets of dark-coloured paper or cloth should be placed behind the sensitive plate and then a thick sheet of glass to give a good even pressure.

If, however, the negative has been stripped from the glass and is in the form of a thin skin, the most perfect contact will be produced by transferring the negative on to the surface of the printing film, in such a manner that it may be removed again after the exposure.

This operation presents some difficulties, but I have found the following method answer well. The sensitised and dried gelatine surface of the printing plate is covered with a very thin even coating of wax dissolved in turpentine or benzole. The plate is then placed in a dish containing sufficient spirits of wine to cover it. The thin negative film is laid down upon the gelatine in its proper position, the plate and film are then removed from the spirit, and the negative film carefully squeegeed into close contact with the gelatine surface. The plate is then covered with a few thicknesses of blotting paper, under a thick glass plate, and allowed to dry. When dry, the plate is ready for exposure. After exposure, the negative film is removed from the gelatine surface; and, if sufficient wax was used and the film is fairly tough, it comes away without tearing. Should it tear, it should at once be dissolved off with ether, or there will be a continuating action of light on the parts of the gelatine surface protected by the negative film, so that they will print darker than the rest of the plate. Before printing, the wax should be removed from the gelatine with turpentine. The object of effecting the transfer in a bath of spirits of wine is, that neither the gelatine, wax, bichromate of potash or negative film are in any way affected by it.

The duration of the exposure to light varies from 10 minutes in the sun for a clear line subject, to from 25 to 50 minutes for a subject in half tones, according to the density of the negative and the intensity of the light. It is almost impossible to judge of the progress of the printing by inspection, and it is necessary to use an *actinometer* as a guide to the exposure. The following form of actinometer has been found to answer well for the purpose. It consists principally of a box, in the lid of which is fixed a translucent scale divided in 14 squares of different densities, No. 1 being

almost transparent, while No. 14 is almost quite opaque; and numbers corresponding to the densities are painted in opaque colour on the scale. The scale is made by taking a collodion negative of a drawing shaded in tints of different strengths, and should be intensified so as to correspond in density with the kind of negatives it is intended to be used with.

The body of the box contains a block for carrying the sensitive surface, which may be spread on paper or on a glass plate, and a strip of vulcanised rubber below it presses the block into close contact with the scale.

I prefer to use in the actinometer a sensitive film of the same composition as the printing plate; small slips of glass are therefore coated with the gelatine mixture, sensitised, dried and exposed to light at the same time and in the same manner as the printing plates, and thus the progress of the action of light can be watched and timed very closely.

When the exposure to light is considered sufficient, the printing plate is removed from the pressure-frame and laid, gelatine side downwards, on a board covered with black cloth. The back, or under surface, of the gelatine is then exposed to light, for about 10 minutes, to thoroughly harden the gelatine and prevent it from swelling too much in the after processes. It is well to conduct this second exposure under a piece of ground glass, in order to prevent any scratches that may be on the back of the glass from showing as white lines in the print. The edges of the plate are then protected by strips of paper coated with solution of india-rubber, and when the india-rubber is dry, the plate is soaked in water until all the soluble bichromate has been removed, and is then ready for printing.

The plates can be printed in a lithographic press, but then they require to be fixed on a level stone with plaster of Paris. It has been found, however, more convenient, and in some respects better, to print them with vertical pressure in an ordinary Albion platen press; and in order to prevent the glass being broken, the bed of the press is fitted with two or three thicknesses of kamptulicon, besides a sheet of vulcanised india-rubber on which the plate rests. It is also desirable to place a piece of white paper over the bedding in order to enable the state of the plate when it is being inked up, to be better seen.

The inking in requires great skill and care on the part of the printer and is the most difficult part of the whole operation. The plate having been well soaked in water is laid on the press, and after being wiped to remove the excess of moisture, is inked in, if a line subject, with an ordinary lithographic roller charged with an ink composed of lithographic chalk ink thinned with a little olive oil, followed by rolling with a smooth roller to clear away the superfluous ink; a mask of the required size is laid on the plate to preserve the margins clean; over this comes the printing paper covered with a piece of soft felt, to drive the paper well into the hollows of

the plate; the tympan is lowered and the impression pulled in the ordinary way. The plate is then damped and inked in again, and so on.

Half-tone subjects are treated in the same manner, but it is sometimes advisable to use two kinds of ink of different consistence or depth of colour; a stiff or dark ink gives force to the shadows, while a thin or lighter coloured one will bring out the delicate half-tones. Rollers made of gelatine, glycerine and castor-oil may be used with advantage, as they drive the ink better into the hollows of the lines than the leather rollers. Capt. Abney, who has given great attention to these processes, says that the great secret of producing good results is to have the command of first rate rollers. Glazed enamelled paper is generally used for printing half-tone subjects, but in some cases unenamelled paper answers well. The most suitable paper for printing seems to depend partly on the composition of the sensitive surface and partly on the ink.

One of the great drawbacks to the extended use of the photocollotype process for the reproduction of maps is the difficulty of making corrections on the plates. When the printing surface is a metal plate or lithographic stone, upon which a map has been either engraved, zincographed or lithographed, additions and erasures may easily be made without any risk of the loss of the printing surface or even of much damage to it. With the tender gelatine films the case is different, and although writing or simple lines may be inserted without much difficulty, it would be almost impossible to successfully alter gradation of shade or to insert shaded details. On the other hand, the taking out of details must be done by some chemical means which must always be attended with the imminent risk of raising the gelatine film from its support and the consequent utter destruction of the printing plate.

As maps, almost more than any other printed subject, require that it shall always be possible to make corrections on the printing plates, it is obvious that the use of any process which will not permit of this being done must be confined more to the reproduction of maps already printed or of an ephemeral character than to the preparation of new or standard ones. And thus, though photocollotype is admirably adapted for reproducing copies of old or other special maps, which are, or can be, finished once and for all, it is not suited for maps on which corrections are likely to be required.

With the plates prepared as described we have found that details may be inserted by two or three methods. The first is by writing in the required additions on the dry gelatine surface, using an ink composed of bichromate of potash, either alone or coloured with Indian ink. After the insertion of the additions the plate is exposed to the light for a few minutes to reduce the bichromate, and may then be washed and printed as usual.

Or an ink composed of solution of chrome alum may be used and will not require exposure to light. In some cases the part to be corrected may be washed over with a solution of bichromate of potash and allowed to dry, and then the required details may be printed in from another negative.

The taking out of details is more difficult and requires care. It may be accomplished by washing the part with a strongish solution of caustic potash or cyanide of potassium. Should a plate print dirty, it may be cleaned up and greatly improved by being washed with a weak solution of cyanide of potassium, or better, with a solution of citric acid, which not only clears up plates that print dirty, but at the same time facilitates the inking in. A weak solution of ammonia is also said to be useful in this respect.

The process just described was found to answer better in Calcutta for line-work than for half-tones, and for the latter the following formula for the gelatine films appeared preferable:—

Gelatine,	1½	ounce.
Glycerine,	1½	dram.
Albumen,	1	ounce.
Bichromate of Potash,	40	grains.
Chrome Alum,	7	grains.
Water,	12	ounces.

The plates coated with this mixture have to be dried in the dark, but in other respects the operations are much the same.

The processes in which a thick film of gelatine is spread upon a glass plate were found to present in Calcutta many inconveniences in the drying of the films, and the tendency there is in dry weather for the films to peel away from the glass plates and utterly break up and destroy the surface of the latter. There is also the constant risk of breaking the plates in the press. I was therefore led to go back to the old process of Tessié du Mothay and Marechal, in which a thin film of gelatine is supported upon a metal plate, and finally succeeded very well with the following method which I have fully described in the '*Year Book of Photography*' for 1877.

A flat plate of copper, such as used for engraving, is finely grained on its best side, and having been carefully levelled, is washed with warm water and coated on the grained side, while wet, with a mixture composed of—

Gelatine (Nelson's opaque),	15	parts.
Water,	100	„
Bichromate of Potash,	4	„
Formic acid (when the former are dissolved),	4	„

The excess is poured off, so as to leave enough to give a thin even coating. Half an ounce of gelatine is more than sufficient to cover 450 square inches of plate.

The plate is then replaced in the drying box and when dry is ready for exposure to light in the usual way; but it will be found desirable, in order to secure perfect contact, to transfer the negative film on to the gelatine surface in a bath of alcohol as before described.

Formic acid varies in strength and other properties, and if it should be found that the films made by the above formula are too soft, the plates may be kept a few days before printing. The addition of a very small quantity of tartaric acid (about $\frac{1}{30}$ of a part) will improve the films in this respect, and so will the cautious addition of some hardening agent, such as chrome alum, glycerine, glucose, honey, &c.

The printing operations are the same as for the plates already described, but the use of glue rollers and vertical pressure will be found advantageous. The thin films have been found to stand the wear and tear of printing well and to have no tendency to chip or tear away from the plates.

In all cases where the photographic image is impressed directly on the printing surface, a reversed negative must be used, as before explained, and these are sometimes rather troublesome to produce. I have lately tried whether the use of this reversed negative could not be dispensed with in the photocollotype process, by taking the negative in the usual way direct on to the thick ground glass plate and then, while still wet and without varnishing, coating this negative with a thin layer of any of the foregoing mixtures of gelatine, either with or without bichromate. When the sensitive gelatine coating is dry, it is exposed to light through the negative on the under side and allowed to print well through the film. This plan was found to have many conveniences to recommend it, and to answer very well for subjects in line, but not for half-tones. For map-work it has the undoubted advantages of perfect accuracy of scale and the greatest possible sharpness of the image.

The foregoing descriptions will give an idea of these interesting processes which are now being very largely used for producing photographic prints of all kinds, though, I believe, the successful working of them still presents some difficulties, even in better climates than India. Against their employment for map-work on the large scale there will, however, always remain the impossibility of joining up several sections of a large map on the printing surface, the difficulty of reproducing the finest tints of a shaded map with a perfectly clean white ground, and, above all, the difficulty of making additions and corrections on the plates.

The accompanying specimen of a reproduction of an old map of Bengal will give an idea of what may be done by the process described at page 93.

VII. Woodbury-type.

We have already seen that the great drawback to the production of photographs in printing ink with continuous gradation of shade, by either photography or photo-engraving, is the necessity for breaking up the continuity of gradation by a more or less marked 'grain', and that this difficulty has been overcome by the photocollotype processes.

By a very ingenious process, invented in 1864, Mr. Walter Woodbury succeeded in solving the problem in another way, and, by a mode of operation analogous to 'Nature-Printing', has been able to produce absolutely permanent prints with such perfect photographic gradation, combined with the most exquisite transparent delicacy and richness of tone, that none but the initiated would know that they were not the ordinary silver prints.

A tissue is first made by coating a tough film of collodion with a moderately thick even layer of gelatine and bichromate of potash, slightly coloured in order to see the progress of the development. When dry, the tissue is laid collodion side next to the negative film, and exposed to light proceeding from one direction only, in order to prevent diffused rays acting through the thick gelatine coating and so blurring the image. This tissue of gelatine and collodion is then temporarily attached to a glass plate and treated with hot water, very much in the same way as in the pigment printing process already described. The whole of the gelatine upon which the light has not acted, and which therefore remains soluble, is dissolved away, leaving an image in relief, the highest parts of which represent the deepest shadows of the picture, while the parts intervening, down to the lowest, represent the intermediate gradations between the deepest shadows and the highest lights.

When dry, the gelatine composing this image will be quite hard and capable of resisting the heavy pressure required to indent it into soft metal, without itself being injured.

The tissue bearing the image having been stripped from the temporary support, is laid face downwards on a sheet or block of lead or type-metal, about $\frac{1}{8}$ of an inch thick, between two finely surfaced steel plates and submitted to the pressure of a very powerful hydraulic press. The prominent parts of the relief are thus forced into the soft metal and produce a mould the deeper parts of which represent the shades and the shallower the lights of the picture. As the relief obtained from gelatine and bichromate of potash alone will impart to this mould a smooth surface without grain, such plates could not be printed with printers' ink, like a copper-plate engraving. Mr. Woodbury therefore uses a semi-transparent ink consisting of gelatine coloured with any suitable pigment.

The leaden plate or mould is laid in a suitable press of peculiar construction* and slightly greased. A small quantity of the coloured gelatine having been poured in a liquid state into the middle of the mould, a piece of suitable paper is laid above it and pressed strongly down, so as to force the ink thoroughly into the depressions all over the plate and squeeze out all the ink between the surface of the metal and the paper in the parts forming the highest lights of the picture. The gelatinous ink is allowed a short time to 'set' and attach itself to the paper; the paper is then removed and brings with it a perfect impression of the picture in coloured gelatine, of different thicknesses corresponding in intensity and gradation of shade to the depth in different parts of the plate. The print has now only to be 'fixed' in a solution of alum and when dry is perfectly permanent and ready to be trimmed and mounted.

The rate of impression is about the same as of ordinary copper-plate printing and may be carried on quite independently of the light. If very large numbers are required of a single subject, it is easy to produce as many printing plates as may be required from the original gelatine relief, which may afterwards be put away and kept indefinitely. The cost of printing is exceedingly small and prints are produced in large numbers at a marvellously cheap rate. As the process requires special mechanical appliances and apparatus it has generally been worked on the large scale by public companies.

The Woodbury-type is unfortunately not well adapted for the reproduction of maps, because it has been found very difficult to produce impressions of large dimensions, and, owing to the peculiar method of printing, it is almost impossible to obtain the clear black lines and pure white ground so indispensable in a good map. The prints also have to be mounted, which is an objection. However, in special cases where the work is within the capabilities of the process, it will be found valuable, because it possesses the great advantage over the collotype processes for the reproduction of half-tone subjects that the printing of an almost indefinite number of copies can be carried on with as perfect certainty as in ordinary lithography or engraving, while in beauty, transparency and delicacy of gradation the Woodbury-type prints are undoubtedly superior to collotypes.

VIII. Photographic Engraving.

As was noticed in the Introduction, the earliest practical process of photography was a method of photographic engraving invented by Nicéphore Niepce, and since his time nearly every great improvement in photography has been applied to this object. Thus, no sooner was the Daguerreotype invented than essays were made by Fizeau, Donné and others to engrave

* For a drawing of this press, see Abney's *Treatise on Photography*, p. 175.

the images produced on the metal plates. In like manner, the earliest application of the peculiar action of the alkaline bichromates upon colloid substances was Fox Talbot's photoglyphic process, which was soon followed by the photo-galvanographic and helioplastic processes of Pretsch and Poitevin. Engraving processes have also been based upon Swan's pigment-printing process, the Woodbury-type and the collotype. With the exception, perhaps, of the second, all these methods, from the earliest to the latest, are in use at the present time in a more or less modified form.

The object of engraving maps upon copper is to obtain a plate taking but little storage room and not liable to break, which shall yield a large number of impressions of uniform quality and, with due precautions, be capable of being preserved in a good condition for printing during any length of time.

Copper-plates have the further advantage that they may be multiplied to any extent by electrotyping, and corrections may be made when required, either on the original plate or on the electrotyped matrix or copy. Transfers may also be made from them to stone or zinc and printed in the same way as ordinary lithographs. This procedure is specially applicable when very large numbers are required or when the subject is to be printed in colours.

Besides these more practical advantages, the superior beauty and finish of copper-plate engraving give it the preference for all maps of a permanent or standard character.

With these objects in view nearly every civilised nation has at least one engraved map giving the results of the State Surveys on a convenient scale for general use. For the same reasons map-publishers generally engrave the maps composing their atlases and other standard publications.

Notwithstanding its many advantages copper-plate engraving is a very slow process and is also expensive, because the art of the engraver is one requiring great artistic and manipulative skill, only to be fully acquired by an almost life-long apprenticeship. Map-engraving, it is true, does not require so high a degree of artistic skill as line or aquatint engraving, but it nevertheless requires a long training, particularly in the more difficult branch of hill-etching which demands almost as much skill to produce first-rate results as ordinary line-engraving.

Although the advantages of photographic engraving as a means of avoiding the long and costly labour of engraving maps by hand are obvious, for various reasons these processes have not yet come into general use. A successful commencement has, however, been made by the Italian and Austrian Governments of employing photography in the production of their engraved maps, and there is little doubt that before long, photographic engraving will be more extensively used for this purpose than it is at present, especially as processes are now available by which gradation of shade

may be obtained without difficulty, and the expensive hand-work of the engraver in biting in or finishing may to a great extent be dispensed with.

The processes of photographic engraving that have been proposed from time to time for producing incised images on metal plates capable of being printed in the copper-plate press, are very numerous. I shall, however, confine myself to those which have been most successfully worked and of which the details have been more or less fully published. Further information on the subject will be found in the special works referred to in the footnotes, and also in Hammann's "*Des Arts Graphiques destinés à multiplier par l'Impression*" and A. Martin's "*Handbuch der Email-photographie und der Phototypie oder des Lichtdruckes*," which both give very complete resumés of the early progress in this branch of photography, with details of many of the processes. The Photographic Journals and the Patent Office records may also be consulted.

The principal methods of obtaining an incised image on a metal plate by means of photography are:

1. Obtaining a photographic image on a metal plate coated with asphaltum and then etching or 'biting in' with acid.

2. Obtaining a photographic image in gelatine on a metal plate and etching the latter with some substance that will not attack the gelatine.

3. Obtaining an image by the direct action of light on a metal plate, as in the Daguerreotype process, then forming a metallic reserve to protect either the lights or shadows of the image and etching with a suitable mordant.

4. Electrotyping from a relief obtained by the swelling or partial solution of a chromated gelatine film, either directly or by the intervention of a cast in wax or plaster.

5. Electrotyping from a relief in insoluble gelatine obtained in the same way as in the 'Autotype' or Pigment-printing process.

6. Electrotyping from a leaden plate on which an image has been impressed from a gelatine relief, as in the Woodbury-type process.

7. Electrotyping from a relief obtained directly on a collodion positive cliché.

It will be seen that these methods divide themselves into two principal groups of etching and electrotyping processes.

Etching processes with Asphaltum.—We have already seen that Niepce in his experiments to find a substitute for lithography, made use of the property possessed by bitumen of Judæa, or asphaltum, of becoming insoluble in oil of lavender and other solvents, after exposure to the action of light, to obtain photographic images on metal plates which were then bitten in with acid, so as to form engraved plates, usually copies of engravings, though he also obtained images from nature.

Owing to the imperfection of photographic appliances in those early days of the art, the results obtained by Niepce could not have been very satisfactory, but with better appliances the same process has yielded in the hands of Niepce de St. Victor, the nephew of the inventor, Amand Durand and others, results which prove its practicability, and its capabilities for reproducing images direct from nature or for copying fine line engravings and similar subjects, for which latter it is much better adapted.*

A process on this principle has been very successfully used at the Imperial State-Printing Office, Berlin, for the engraving of plates for bank notes and other purposes, and I have also tried it myself with fair success.

The following outline will give an idea of the operations.†

A perfectly smooth copper plate, having been thoroughly cleaned and polished, is coated with a solution of asphaltum in turpentine, to which a little oil of lemon is added. It is then carefully dried in the dark so as to preserve an even coating, free from dust.

The image may be impressed upon the sensitive surface by sun-printing through an ordinary negative on glass, but as there is by this plan great risk of losing perfect sharpness by want of close contact between the glass and the copper plate, it is better to remove the collodion film from the negative and transfer it on to the surface of the asphaltum, so that it may be in absolute contact with it all over, and thus secure the utmost possible sharpness of the image. The collodion film is loosened from the glass in an acid bath, containing 1 part each of sulphuric and acetic acids in 320 parts of water, and the transfer is then effected in a bath of 1 part glycerine and 4 parts of water. The transferred film being dry, the plate is ready to be exposed to light, and as the asphaltum is not very sensitive, the exposure is somewhat long—extending from 6 to 36 hours; but it is better to over-expose and to work in diffused day-light rather than in the full sunshine.

When the plate is judged to have been sufficiently exposed, the collodion film is removed and the asphaltum surface is rubbed lightly with a tuft of cotton dipped in olive oil, to which after a short time a little turpentine is added. The image gradually begins to appear, and by degrees the unaltered asphaltum is all removed, so that the design appears in clear brown upon the polished copper. The plate is then washed with soap and water and allowed to dry.

The next operation is the etching or biting in of the image. The back of the plate having been well coated with a thick varnish of asphaltum, to protect it from the action of the acid, the plate is plunged into a trough

* See '*Traité pratique de Gravure Héliographique sur Acier et sur Verre*', par M. Niepce de St. Victor.

† Full details will be found in my '*Report on the Cartographic Applications of Photography*,' p. 79.

containing a mixture of 1 part chlorate of potash, 10 parts muriatic acid and 48 parts water, and allowed to remain till the weakest lines of the drawing begin to appear. It is then well washed and the asphaltum covering the lines is removed with benzole. The design will now be seen standing in a slight relief, and an electrotype must be made in order to obtain a printing plate from which impressions may be taken in the ordinary way. The sharpness of the lines is better preserved by making a relief and electrotyping, than it would be by biting in.

The best results by this process are obtained from subjects in line, and even with these the operation of 'biting in' demands a little manipulative skill. Good results have, however, been obtained in reproducing half-tone subjects, but they require the greatest skill on the part of the manipulator and generally much re-touching by a practised engraver.

A modification of Niepce's process, by which good results have been obtained, has been introduced by M. Négre, it is briefly as follows:

A plate of steel is covered with a coating of bitumen or bichromated gelatine and exposed to light under a negative. After development by a suitable solvent, which removes the parts not acted on by light, the plate is placed in a solution of gold and, by means of a galvanic battery, a thin regular coating of gold is deposited on those parts which present a clean metallic surface; the remainder of the sensitive coating is then removed, and a beautiful damascened design in gold is obtained. The gold adheres well to the metal surface and as it is not attacked by the etching liquid, the design may be etched without injuring the ground of the plate.

This process also appears only suitable for line work, though it is said that satisfactory results in half-tone have been obtained with it.

M. Baldus, of Paris, is said to have used a similar process, but to have etched his plates in a solution of sulphate of copper by attaching them to the positive pole of a galvanic battery.

The processes dependent on the use of asphaltum are all more or less slow and uncertain in practice, and if not already quite abandoned in favour of the quicker and more certain processes dependent on the use of gelatine and bichromate of potash, are rapidly becoming so, especially as their usefulness is almost entirely confined to reproducing subjects in line. Exceedingly fine results can, however, be produced in this manner, and it is particularly valuable in cases where an 'etching' or 'biting in' process is required, because the bitumen forms a much better 'resist' for the acid or etching liquid than does gelatine, as we shall now see.

Etching processes with Gelatine.—In 1852, Mr. Henry Fox Talbot brought forward a method of photographic engraving called 'Photoglyphy,' which is of some interest as being the first practical photographic process founded on Ponton's discovery of the decomposition of bichromate of

potash in contact with organic matter under the influence of light. Talbot found that by the action of light, a dried film of gelatine mixed with an alkaline bichromate became impermeable to certain fluids in proportion to the intensity of the action of the light upon it. He coated steel plates with a thin film of gelatine and bichromate of potash, and after exposure to the light under a photographic positive, he etched the image so produced with a solution of bichloride of platinum which, penetrating the unaltered gelatine in the parts protected from the light and attacking the underlying metal, produced the shadows of the resulting picture. Some very promising results were obtained in this manner, and great expectations were entertained of its utility in producing engraved plates for book illustration and other purposes. These hopes, however, have not been fulfilled and the process, though remarkable as the first of the many valuable methods of photographic press-printing dependent on the use of gelatine and the alkaline bichromates, has inherent defects and difficulties which seem to render it of little practical value.*

M. Baldus has successfully employed a modification of the photoglyphic process for line-work.† He coats a copper-plate with gelatine and bichromate and exposes it under a negative or a positive, then etches in a solution of perchloride of iron, which attacks the copper in all the parts not acted upon by the light, and thus a first relief is obtained. As this relief is not sufficient, the plate is inked in with a printing roller, when the ink attaches itself to the parts in relief and protects them from the action of the etching liquid. This procedure is repeated till the desired effect is produced. If a negative is used an incised plate is obtained, which may be printed in the copper-plate press. If a positive is used the image is in relief and suitable for being printed with type. I have found that the reliefs obtained in this way are exceedingly sharp, though the gelatine films will not stand the action of the etching fluid for very long.

Messrs. Leitch and Co., of London, have lately introduced a similar process, called by them 'Photogravure.' It appears to be due to M. Garnier, who has had great experience in these processes and produced some very fine results. The method of working is a secret, but it is said that a metal plate is coated with a sensitive composition capable of resisting the action of acids. The photographic image is impressed on the sensitive surface through a negative and is then etched with perchloride of iron. The etching is said to be to a certain extent automatic, that is to say, the etching action on the lines ceases at different periods in proportion to their fineness.

* A full description of Talbot's process, with specimens, will be found in the appendix to the English translation of Tissandier's '*History and Handbook of Photography*,' edited by J. Thomson.

† See the above work, p. 207.

Daguerreotype Etching.—Many attempts have been made to engrave the beautiful and delicate photographic image formed on the Daguerreotype plate. Thus, Donné simply etched the image with dilute nitric acid, which attacked the silver forming the shadows, leaving the whites protected by the mercury untouched. Grove etched the plates with the aid of the galvanic battery. Fizeau first etched as deeply as possible with dilute muriatic acid and then, having filled up the hollows with drying oil, deposited gold upon the lights; the oil having then been removed, the plate was bitten with dilute nitric acid. In order to render the silver plate more capable of standing the wear and tear of printing it was covered with a thin film of copper, which could easily be removed and renewed when required.

Other processes were also put forward, but they all failed, from the difficulty of biting the image to a sufficient depth and of obtaining the requisite 'grain' to enable a large number of impressions to be pulled off. None of them seem to have ever come into practical use and, like the Daguerreotype, they have almost fallen into oblivion.

If with the superior knowledge and appliances of the present day, any such process could be successfully worked, it would probably offer many advantages over any other etching process, especially for maps and other works in line.

Several ingenious processes of chemical engraving applicable to photography have been proposed by Messrs. Garnier and Salmon, Vial, Dulos and others; but as they do not appear to have come into practical use, it will be unnecessary to enter into details regarding them. Descriptions of them will be found in Roret's '*Manuel du Graveur*'.

Though they have the advantage of rapidity, all these processes, in which the image is obtained by etching or biting in with acids or other etching fluids, are open to the objection that for all subjects containing fine and delicate lines the etching and stopping out require almost the same manipulative skill and care as in ordinary engraving, and the processes consequently become expensive to work. There is also a tendency for the lines to become coarse and heavy. In those gelatine processes in which the etching fluid acts through the gelatine it gradually loosens the latter from its support and attacks the parts which should not be bitten at all. These defects are to a great extent obviated in the processes we are now about to consider, in which the printing plates are produced by the electro-deposition of copper on the photographic image.

Electrotyping methods.—In nearly all the electrotyping methods the printing plate is obtained by depositing copper on a gelatine relief obtained by the agency of light, or on a cast in plaster, gutta-percha, &c. taken from such a gelatine relief.

If a dry film of chromated gelatine on a suitable support be exposed to

light under a photographic cliché, and then plunged into hot water, the parts acted on by light being insoluble will remain on the support in different degrees of relief according to the intensity of the light, while the unexposed parts will be washed away. An image in high relief formed of hard and insoluble gelatine will thus be obtained, from which a cast or electrotype in intaglio may be made.

If, however, instead of using hot water, the plate be plunged into cold water, the gelatine will be found to absorb water and swell up in the parts protected from the light, while in the parts acted on by the light it will only slightly absorb the water, and these parts will thus form hollows. The power of absorbing water will also be found to be in exact proportion to the degree of protection from light. In this case, an image in low relief is obtained which may also be moulded from, or electrotyped.*

Upon these two principles several processes of producing printing-plates both for copper-plate and letter-press printing have been founded with more or less success.

The first process of the kind was Paul Pretsch's 'Photogalvanography', invented in 1854. He appears at first to have obtained his plates by coating a glass with gelatine and bichromate, exposing to light and then washing away the soluble gelatine and taking a mould of the resulting relief, in gutta-percha, from which an electrotype was made in the usual manner.*

This process gave fair results both in line and half-tone, but, owing to the washing away of the soluble gelatine being effected on the side of the film exposed to light, the plates were defective and required a good deal of touching up by skilled engravers, which vastly increased the expense of their production. The process failed as a commercial speculation.

Almost immediately afterwards, in 1855, Poitevin published methods of obtaining plates from the gelatine reliefs obtained by swelling the sensitive films in cold water. Plaster casts were either made from them or the gelatine surface itself was metallised and electrotyped in the usual way.†

This method produced tolerable results, though the prints were always somewhat coarse, owing to the fact that swollen gelatine will not give the same sharpness as when dry.

Both these processes were more or less unsuitable for reproducing subjects in half-tone—Pretsch's because in the process of washing away the soluble gelatine, the lighter half-tones were liable to be lost—Poitevin's because of the difficulty of keeping the swelling in proper relative proportion, owing to more absorbent parts of the film lying underneath less absorbent parts. Both processes also failed to give the necessary 'grain,' without which the proper inking of the engraved plates could not be effected.

* See '*Journal of the Photographic Society of London*,' Vol. III, p. 58.

† See '*Traité de l'impression photographique sans sels d'argent*,' p. 49.

Various attempts were made to improve on these processes, but unsuccessfully, until M. Placet showed that it was necessary to adopt in them the same principle of exposing on one side of the gelatine film and developing on the other, which, as we have seen, had previously been shown to be necessary for the preservation of the half-tones in the pigment-printing process, and for a similar reason.

M. Placet indicated several ingenious ways of obtaining his results.* They may, however, be briefly summed up as follows:

A film of chromated gelatine is exposed under a transmitted positive cliché, so that the light acts on the under side of the film; this is done either by covering the collodion side of the cliché itself with the sensitive coating, or by using a thin transparent sheet of transfer collodion or mica as a support for it. After exposure to the light, the film is soaked in water, whereupon those parts which have been protected from the light swell up in proportion to the amount of the action of light upon them. By treating the mould in relief thus obtained with metallic solutions, an electrotype copy in copper may be produced, which can be printed from in the copper-plate press.

If a negative cliché is used, the unaltered gelatine must be dissolved or a second electrotype must be made.

M. Placet also suggested the employment of a sensitive surface which would become soluble under the influence of light, such as a mixture of gelatine, or other colloid, with perchloride of iron and tartaric acid, as recommended by Poitevin for pigment-printing. In this case the solvent acting on the exposed side hollows out the image, in the same way as an etching fluid does on copper, but with the advantage that each line has only the exact strength given to it by the intensity of the cliché. Or the altered parts of the gelatine film may simply be swollen with cold water, producing an image in relief. In either case, a mould is taken from the gelatine and electrotyped, or copper may be deposited on the gelatine itself.

By his process M Placet was able to obtain very perfect gradation of shade in the half-tones of his pictures, with a fine natural grain produced by some means which he did not divulge. He has lately, however, described a method of producing the grain, which consists in plunging the gelatine plate into a solution of bichromate of potash and then treating it with a solution of protosulphate of iron containing acetic acid.† The principle he lays down is first to treat the gelatine with a solvent and then with a solution of some substance that will tan or contract it.

Messrs. Fontaine, Avet and Drivet have also proposed similar processes, in which they have partially overcome the difficulty of obtaining a proper

* See Davanne, '*Les Progrés de la Photographie*,' p. 185.

† See '*Bulletin de la Soc. Franc. de Photographie*,' Vol. XXIII, p. 130.

'grain' by interposing between the cliché and the gelatine film a fine network or an impression of an engraved or roulette tint; but these artificial grains have a disagreeable effect, and the methods seem to have fallen into disuse, except for line-work and photo-typography, which will be described further on. Avet's process is, however, I believe, still in use for producing the maps of the Italian Surveys.

Geymet's method.—The fourth method, that of electrotyping from a gelatine relief obtained by the pigment-printing process, is somewhat similar in principle to Placet's process, but as there are important differences and the process appears likely to prove of some utility, it may well be treated separately.

According to M. Geymet, who has very fully described the process and all the manipulations of preparing and electrotyping the reliefs in his "*Gravure Heliographique*," it was the invention of M. Audra, a French amateur.

Pigmented gelatine tissue is sensitised and exposed to light exactly in the manner described at p. 78 for the 'Autotype' process. It is transferred to a smooth glass or a polished copper plate, developed in warm water, and when dry is metallised and electrotyped. If the subject is one in line or dot only the above operations are sufficient, but if the subject is a photograph from nature, or any other with gradation of shade, it is necessary to obtain a 'grain', and this M. Geymet does by taking a copper-plate with its surface grained or engraved with a ruled or roulette tint, inking it up in the ordinary way and then covering it with a coating of transfer collodion. When dry, the film of collodion is stripped off the plate and carries with it the impression of the grain. This film is then placed between the cliché and the sensitive gelatine film and serves to break up the shadows in the more transparent parts of the cliché.

A similar process has been used at the Depôt de la Guerre, in Belgium, for the reproduction of maps.*

Last year, whilst making some experiments on this process, I succeeded in obtaining the necessary 'grain' by chemical means which produce a finer and less artificial effect, and I have also made a few other modifications in the process, which may be worth recording at length.

A piece of the ordinary autotype tissue is sensitised in a 5 per cent solution of bichromate of potash. When dry, it is exposed to light under a reversed negative and then transferred in cold water to the surface of a well polished copper plate and squeegeed down into close contact with it. In order to prevent subsequent adherence to the newly deposited copper in the electrotyping bath, the copper plate is silvered by rubbing it with a little of the following solution mixed with tripoli.

* See Maës and Hannot '*Traité de Topographie, &c.*,' p. 330.

Nitrate of Silver, ...	1	part.
Cyanide of Potassium, ...	10	„
Water, ...	100	„

The gelatine tissue attached to the copper plate is allowed to dry, and then developed in warm water in the usual manner, great care being taken not to loosen the lines, an accident which is very liable to happen, though the preliminary drying of the tissue before development tends to prevent it.

When the image is quite clear from all soluble gelatine, the plate is well drained and plunged into a bath containing—

Tannin, ...	5	parts.
Strong Spirits-of-wine, ...	100	„

This at once removes all moisture from the gelatine relief, hardens it, and gives it a fine grain, coarser in the shadows than in the lights. The plate remains a few minutes in this bath till the action is complete in the deepest shadows; the tannin is then washed off with a little spirits-of-wine, and the plate is allowed to dry.

The gelatine relief has now to be prepared for receiving the electrotype deposit. A band of copper having been soldered to it, the back of the plate is coated with Brunswick black, to prevent deposition of the copper upon it. When the backing is dry, the margins of the picture are cleaned with a little of the silvering solution. The gelatine surface then receives a very slight coating of wax dissolved in turpentine, which is well polished off, and is rubbed over with fine plumbago or silver-bronze powder to render the surface conducting. The plate is then ready to be placed in the depositing bath.

Any good electrotyping arrangement may be used, but I prefer a Smee's battery with a separate depositing trough, containing a solution of 10 parts each of sulphate of copper and sulphuric acid in 100 parts of water.

A plate of copper, to serve as an anode and connected with the silver plate of the battery, is laid horizontally about an inch above the bottom of the depositing trough which should be large enough to allow the plate bearing the gelatine relief to be slipped under the anode. The relief-plate is connected with the zinc plates of the battery and, when everything else is ready, the circuit is completed by slipping it into the depositing trough under the anode. By laying the plates horizontally in this manner the deposit is more even and the gelatine film seems to be more readily covered with copper.

When the deposit of copper is of sufficient thickness it is separated from the matrix, and only requires a gentle 'oil-rubbing' to be fit for printing.

The plates obtained by this method show very good half-tone with an almost imperceptible grain, giving the effect of a fine chalk-drawing.

I have lately tried to obtain the images upon the copper by the double transfer process, making use of a flexible temporary support, consisting of paper coated with india-rubber, as first proposed by Swan, which can easily be removed with benzole after the transfer of the gelatine image to the copper. The 'grain' is given to the image by soaking it in water after the removal of the india-rubber paper, and then applying the solution of tannin in alcohol. This plan seems likely to be successful, if so, it will greatly simplify the operations and enable engraved plates to be obtained from any ordinary negative without the trouble of reversing.

By electrotyping direct from the gelatine relief, the results are always rather heavier and coarser than they should be, because, although hardened and insoluble, the gelatine relief can always absorb a little of the copper solution in the depositing trough and consequently the image swells and loses sharpness.

The strong tanning given to the gelatine film and the preliminary coating of wax before metallising the surface obviate this defect to a considerable extent; but it may perhaps be better to obtain a matrix in lead by pressure from the gelatine relief, and then to obtain the printing plate by electrotyping twice from the lead matrix. This is a more round-about and expensive method, but is likely to yield finer results and has been adopted by Woodbury and Rousselon in the processes next to be considered.

The process is simple and if it could be successfully worked out it might be usefully employed in this country in reproducing shaded maps and for other miscellaneous purposes. It has the very great advantage over photo-collotype that the plates can be corrected, if necessary, and can be printed in any numbers in the ordinary copper-plate press without risk of breakage or damage to the printing surface.

Woodbury-type methods.—It has already been shown that in the Woodbury-type process the photographic image is impressed into a soft metal plate by means of a relief in insoluble gelatine on a collodion support, and that instead of impressions being printed in ordinary printers' ink they are made in coloured gelatine. In such prints the gradation of shade is continuous and there is no perceptible grain.

Mr. Woodbury has proposed an ingenious method for obtaining gelatine reliefs with a granular surface, so that, when impressed into soft metal, electrotypes in copper may be obtained from the latter, which will serve as printing-plates for printing with printers' ink in the copper-plate press, and yield superior results to those obtained by electrotyping immediately from the gelatine relief.

A plate of glass is waxed and coated with a thin film of collodion, and a

mixture of gelatine and bichromate of potash, containing a quantity of fine emery, powdered glass or charcoal is poured over it and allowed to 'set'. The gelatine film is then dried and taken from the glass, and the collodion side exposed beneath a negative. After a sufficient exposure, it is temporarily attached, on the collodion side, with india-rubber solution, to a sheet of glass and washed in warm water.

The resulting granular image is then pressed into a sheet of soft metal by means of the hydraulic press. The soft metal plate has an electrotype made from it in copper, and another plate, subsequently covered with a coating of iron, is again made from this to serve as the printing-plate, the first copper plate being kept as a reserve.*

Mr. Woodbury also describes another method which in some respects resembles Geymet's, before described.

Paper is successively coated with three or more mixtures of gelatine, bichromate of potash and some granular substance in different degrees of fineness—first with the coarsest and lastly with the finest. When dry, the tissue is exposed under a negative, transferred under water to a finely polished plate of zinc or steel, then washed in warm water as usual, and when dry is ready for pressure into the soft metal block. In this case, the light tones are composed of the finest grains and the shadows of the coarsest.

M. Rousselon, the manager of Messrs. Goupil's photographic works at Asniéres, near Paris, has obtained engraved plates with remarkably good half-tones by a process somewhat similar to the Woodbury-type, which is also largely worked by Messrs. Goupil. The peculiarity is in the grain, which is obtained by the addition to the sensitive mixture of gelatine and bichromate of some substance which has the property of causing the film to become granular under the influence of light, the granular effect being increased in proportion to the intensity of action of the light. The other operations are the same as in the first of Mr. Woodbury's processes just described. The details of this process are a secret, but it is said that the substance used for producing the grain is chloride of calcium.

I am not aware of either Woodbury's or Rousselon's processes being utilised for the reproduction of maps, but in certain cases they could, no doubt, be usefully employed. The only difficulty seems to be that an immensely powerful hydraulic press is required for large subjects.

Photo-mezzotint.—The Editor of the '*British Journal of Photography*' has lately suggested a process of photo-mezzotint engraving founded on the 'dusting on' or 'powder' process, already alluded to.†

A polished steel plate is thinly coated with—

* '*British Journal Photographic Almanac*,' 1872, p. 40.

† '*British Journal of Photography*,' Vol. XXIV, p. 170.

Saturated solution of bichromate of ammonia,...	5	drachms.
Honey,.....	3	„
Albumen,.....	3	„
Water, ...	1½	pint.

When the coating is thoroughly dry, the plate is exposed to light under a transparency. A large camel's hair brush is charged with a mixture of the two finest kinds of emery powder, and applied with a circular whisking motion all over the surface. The powder attaches itself to those parts of the plate on which the light has not acted, precisely in proportion to the amount of protection they have received, owing to the unaltered parts of the film attracting moisture and becoming 'tacky.' The most 'tacky' parts, forming the deep shadows of the picture, will attract the coarsest particles of the emery, the finer parts will take finer emery and the highest lights will take none at all. When the picture is fully developed, it is placed face to face against a polished plate of softer metal and passed between a pair of rollers, so that the emery powder image may be indented into the polished metal. The plate is then burnished in parts by a skilled engraver and when the desired result is obtained, is printed in the usual way in the copper-plate press.

This process seems capable of rendering useful service in the reproduction of maps.

Scamoni's method.—The last method is that recommended by Herr G. Scamoni, of the Imperial Russian State-paper Office, and is fully described in his '*Handbuch der Heliographie*,' already referred to. The results are exceedingly good, but the process is only suitable for line work.

Herr Scamoni having obtained a suitable negative of a drawing or other line subject, makes a positive copy of it in the camera by the wet collodion process, and after fixing, treats this positive with various successive intensifying solutions, so as to give it a very sensible relief. After drying the plate is varnished with a thin varnish and coated with fine plumbago, after which it is electrotyped in the usual way.

In the specimens I have seen of this process the lines are exceedingly sharp and fine, and it would seem well adapted for map-work.

A photo-mechanical process has lately been introduced by Messrs. Aubel and Kaiser of Lindenhohe, near Cologne, and called 'Aubeldruck.' The results for line-work are very superior but the process is a secret. It is believed to consist in some method of etching a glass negative, so that prints may be obtained direct from the glass surface or by transfer to stone.

In all cases where the printing-plates are obtained by electro-deposition of copper, and many copies are required, it is necessary to protect the engraved surface of the plate with a coating of iron by the process known as 'acierage' or 'steel facing.' This enables a very large number of copies

to be printed without deterioration of the plate, and the coating can easily be removed and renewed whenever required. Details will be found in Ure's '*Dictionary of Arts, Manufactures and Mines*,' article ENGRAVING.

IX. PHOTO-TYPOGRAPHY.

The object of the photo-typographic processes is to obtain a surface block by photographic agency, that may be set up with type in the same way as woodcut, stereotyped or electrotyped blocks, and be printed in the ordinary printing press. The process offers great advantages in the rapidity with which the blocks may be made and printed off in large numbers. Up to the present time no entirely satisfactory method has been discovered for printing subjects in half-tones in this way, though Mr. Duncan Dallas has produced some very promising results. The processes are, therefore, almost entirely limited to the reproduction of subjects in line or dot alone.

The operations in this branch of photographic reproduction are based upon exactly the same principles as the photo-engraving processes just considered, and in some of them the only difference is the substitution of a positive cliché for a negative, or *vice versâ*.

The existing processes may be divided into three classes:

1st. Those in which a mould is made from a relief in swollen gelatine.

2nd. Those in which the image is obtained in asphaltum or gelatine on a metal plate and bitten in.

3rd. Those in which an image in a waxy and resinous ink is obtained by the methods described under the head of photozincography, then transferred to a metal plate and bitten in.

Moulding Processes.—Of the first class several methods have been introduced from time to time, but they are all on the same principle and are modifications of Pretsch's and Poitevin's processes already described, differing, as a rule, merely in technicalities which being trade secrets have not been fully published.

The following method is a typical one. A glass plate or other suitable surface is coated with a mixture of gelatine and bichromate of potash and when dry exposed to light under a negative. After this, it is immersed in cold water till the parts unaltered by the light, which represent the whites of the original drawing, swell up to the required height, leaving the lines quite sunk. The plate is then removed from the water and, the superfluous moisture having been carefully blotted off, is ready to have a cast made from it.

This may be done in two ways first, by metallising the gelatine surface either by means of plumbago or bronze powder, or by reducing silver upon it by applying a solution of nitrate of silver followed by treatment with a

solution of pyrogallic acid or of phosphorus in bisulphide of carbon. The gelatine relief then receives a thin deposit of copper in the usual way. The thin copper electrotype is backed up with type metal, planed and mounted on a wooden block so as to be of the height of type.

This method gives the finest results but takes time.

The second method is to take a cast of the gelatine relief in type-metal. A cast in plaster, wax, &c. must first be taken from the gelatine, a second cast in plaster is made from this, and then stereotyped in the usual manner. This method is quicker than the last, but the results are coarser.

These processes are now largely used for illustrations in books and newspapers, but, so far as I know, have not been regularly applied to the reproduction of maps.

Etching processes.—The processes in the second class, in which a metal plate on which the image has been obtained on a sensitive coating of asphaltum or gelatine is bitten in with an etching liquid, though capable of giving very perfect results, are not, I believe, so much used as the other methods which are quicker and more simple.

A photographic image is impressed from a reversed negative on a copper or zinc plate prepared as in the Berlin engraving process described at p. 103, and, after development with olive oil and turpentine, is bitten in so as to yield an image in sufficiently high relief for surface printing, the precaution being taken of protecting the finest parts of the work as soon as they are sufficiently bitten, by covering them with stopping-out varnish.

If the sensitive surface is chromated gelatine, the soluble gelatine may be removed or not, but the etching fluid must be such that it will not dissolve or remove the gelatine from the surface of the plate—solutions of perchloride of iron, bichloride of platinum, nitrate of silver in alcohol, bichromate of ammonia in dilute sulphuric acid are some of the most suitable mordants for the purpose. In any case, the full amount of relief cannot be obtained through the gelatine at one operation. After the first biting-in the gelatine film must be removed and the lines protected from the further action of the etching fluid.

Gillotage.—The last class, in which a photographic transfer in resinous ink is made on a metal plate, and then bitten in, comprises the simplest and most largely used of these processes.

The process generally employed is substantially the same as Gillot's "paniconography", now commonly called 'Gillotage,' which is largely used for illustrated papers and various other purposes.

A polished zinc plate, which has been strongly varnished at the back to protect it from the acid in the subsequent operations, receives a transfer in greasy ink, either from an engraved copper plate, a lithographic drawing on paper, or a photo-transfer print prepared as for photozincography.

The plate is then etched in the usual way and rolled up with a varnish ink, containing a large proportion of resinous matter; it is then dusted with powdered resin, which sticks to the lines and renders them more capable of resisting the acid; the superfluous resin is brushed off and the plate is gently heated.

The edges of the plate and the large white spaces are covered with shellac varnish and when the varnish is thoroughly dry, the plate is plunged into a trough containing very weak dilute nitric acid, kept in constant motion, and is left until the finest parts are sufficiently bitten, which generally takes about a quarter of an hour; it is then taken out of the trough, washed, dried, and placed on a sort of grating over a charcoal fire. Under the influence of the heat, the coating of ink and resin on the lines, being gently softened, flows down and protects the sides of the hollows formed by the first biting, filling up the spaces where the lines are very close. As soon as this effect is produced the plate is allowed to cool and then inked with a lithographic roller, as if a proof was going to be pulled. It is again dusted with powdered resin, and is then ready for a second biting in, which is to attack the parts somewhat lighter, and therefore may be effected with stronger acid.

The operations of inking, dusting with resin, heating and biting with acid are repeated several times till the plate presents only a uniform black colour. Then the plate is bitten with strong dilute acid which bites out the parts to be left completely white. The large whites, which have been covered all along with a strong shellac varnish, are then cut out with a saw, and the plate is ready to be mounted on a wooden or leaden block for printing. These plates usually require considerable touching up to take off the ragged edges of the lines caused by the spreading of the ink, though this may also be done by repeating the inking and biting in, so as to remove the steps formed by the successive bitings.*

This process has been applied at the Imprimerie Nationale, Paris, for producing large geological maps, but the special precautions that had to be taken in "overlaying" the plates in the press so as to print properly were very tedious, and must have largely increased the expense and lessened the use of the process. Messrs. Yves and Barret, of Paris, are said to use it largely for reproducing maps and engineers' plans, &c.

Photo-blocks in half-tone.—Many attempts have been made from time to time to obtain surface blocks from photographs from nature and other shaded subjects, but with imperfect success. If this object could be successfully attained, it is easy to understand that it would be of immense value for book and newspaper illustration and many other purposes. There are, unfortunately two grave difficulties to be overcome—one caused

* See Davanne, '*Les Progrès de la Photographie*,' p. 201.

by the fact that to produce a successful printing block the surface of all the lines or dots which receive the ink must be very nearly on one uniform level, and therefore the moulding processes above described are inapplicable. The second and greater difficulty is to obtain a suitable grain to break up the continuous gradation of shade in the photograph.

M. Rodriguez, of Lisbon, has proposed an ingenious method by which promising results have been obtained. He makes a paste of sugar of milk, or some other substance in powder soluble in nitric acid, with a little oil of lavender and bitumen, and adds a sufficient quantity of it to a solution of bitumen in turpentine. The metal plate is thinly coated with this in the ordinary way, exposed to light and developed with turpentine. The plate is then plunged into a bath of dilute nitric acid which gradually penetrates the resinous coating and dissolves the substance used for forming the grain, breaking up the preparation more or less according to the thickness of the bitumen, and thus reproduces the half-tints of the originals.*

In many processes of collotype the gelatine film presents a very marked grain, which may be coarse or fine according to the composition employed. It is probable, though I have not tried it nor, so far as I can recollect, seen it proposed, that blocks showing very fair half-tone could be obtained by taking a print from such a plate with a grain, transferring it to zinc and then biting it in by a method similar to Gillot's already described. Very great care would have to be taken in the successive etchings to preserve the uniformity of surface and protect the finest tints from being bitten too much.

The prints in half-tone obtained by Mr. D. Dallas' process, known as "Dallastint", appear to have been produced by some such method. This, however, is only a conjecture on my part, because no details of the process have been published.

M. Rousselon has, I believe, obtained fair results by similar transfers from his engraved plates, and it is probable also that a transfer to zinc from one of the plates, prepared by the modification proposed by myself of Geymet's photo-engraving process, bitten in in the same way, might also answer the purpose, though the grain is perhaps scarcely strong enough.

Details of several of the methods of photo-typography will be found in Motteroz's "*Essai sur les gravures chimiques en relief*" and Scherer's "*Lehrbuch der Chemigraphie.*"

X. Miscellaneous Processes.

In addition to the processes by which photographic prints are obtained directly by the aid of light, there are several ways in which photography can be employed as a useful auxiliary in obtaining correct tracings for the

* See '*Bulletin de la Soc. Franc. de Photographie,*' pp 208, 254.

use of the draughtsman, engraver or lithographer, thus saving all the labour of hand-tracing and obtaining also a far more accurate image than could possibly be obtained in any other way.

Blue-Prints.—It is well known that when photographed a pale blue colour acts exactly as if it were white. If, therefore, we can obtain by photography an accurate image of any original drawing or other subject in pale blue ink, either on the same, an enlarged or reduced scale, it will be possible to redraw the whole or part with black ink over the blue print, in a style suitable to be again reproduced by photography, without fear of obtaining a double image. It will also be obvious that the blue ground-work will be more complete and more accurate than any tracing by hand or pantograph could possibly be.

It has already been stated that this method has been extensively used in the Survey of India for making reductions of maps to smaller scales, and at the same time generalising the details on the large-scale maps so as to adapt them to and render them more suitable for the smaller scale.

The same system may be applied to the production of maps or plans in several colours, thus: supposing a map is to be reduced and printed in three colours, black for the outline and names, brown for the hills, and blue for the streams and other water.

Three blue prints are given to the draughtsman who draws on the first only the outline and names, on the second the hills, and on the third the water. These three drawings are then very carefully photographed all on the same scale, and transfers are made from them on to three stones or zinc plates, which are then used for printing the different colours of the map just as in ordinary chromo-lithography.

There is no limit to the number of colours that may be employed, and as the blue-prints are all on the same scale, very perfect 'register' may be secured, if due care be taken in the drawing and subsequent photographic operations.

The advantage of using photo-zincography for preparing the blue-prints is that in reducing a large-scale map, the transfers of the several sections may be joined together and printed off in one sheet, and thus may be redrawn in a more complete manner than if the sections had each to be drawn separately and afterwards joined up.

It is not, however, always desirable or possible to obtain the blue prints by photozincography, and they may be obtained in a more direct manner by coating paper with bichromate of potash and gelatine, exposing under a negative, well washing the print with hot water to dissolve the gelatine, then steeping it in a solution of proto-sulphate of iron, again well washing and then applying a solution of ferrocyanide of potassium, and finally well washing. A pale blue print is thus obtained which will answer

every purpose. The 'cyanotype' process, before described, might also be used, but the blue is much more intense and would be liable to produce a double image on the copy.

Besides its uses in the Survey Department, the blue-print method is also appreciated and utilised by engineers and other public officers in India, who desire from time to time to show alterations or improvements on a standard plan, or wish to make use of a standard map for showing their own special requirements.

Bichromate-prints.—In the case of miscellaneous subjects which it is desirable to lithograph, photography can also be usefully applied in giving the lithographic draughtsman an accurate tracing over which he may make his transfer-drawing in the usual way. This was formerly done by making a silver-print on the required scale, and then either tracing over it on lithographic tracing-transfer paper, or coating the print itself with the composition used for lithographic transfer paper and re-drawing on the print itself; but in either case, the dark colour of the photograph interferes very much with the drawing.

A method of overcoming this difficulty has been suggested by Mr. Fraser S. Crawford of the Government Photo-lithographic Office, Adelaide, S. Australia, and has proved exceedingly useful here in Calcutta. A print is taken from the negative, on the paper prepared with gelatine and bichromate of potash for the photozincographic transfers, but it must be printed as deeply as possible, so that the lines may remain clearly visible after the bichromate has been washed out. Instead of inking the print, it is simply washed till all the soluble bichromate is removed, and is then dried. The surface of the print is coated with the ordinary composition of starch or isinglass used for preparing lithographic transfer paper and, according as the drawing is to be executed with the pen or chalk, receives a smooth or grained surface by passing it through the press either on a polished or grained copper plate. The draughtsman then makes his drawing with autographic ink or lithographic chalk over the faint russet image on the photographic print. An ordinary silver-print can be given as a guide in cases where the bichromate print is not sufficiently distinct for the details to be easily made out. This method is very suitable for copying maps, sketches, or photographs from nature, especially if the former are to be on a smaller scale than the original. The light colour of the photographic print renders it easy to see the effect of the drawing above it. The saving of time and labour in tracing and the superior accuracy of the ground-work are also great advantages gained by its use.

Photographing on Stone.—The following method of photographing direct on stone may sometimes be of use with the same object, when the lithographic drawing is to be made on the stone itself and not transferred.

The surface of the stone is made as level as possible and carefully polished, it is then washed with an 8 per cent solution of chloride of calcium and dried. A 12 per cent solution of nitrate of silver is then washed over the stone in the dark, and when dry it is exposed to light under a reversed negative. The print is fixed with a 20 per cent solution of hyposulphite of soda, and then well washed with plenty of water to remove all traces of the hyposulphite.

This method is used at the Topographical Department at the Hague to give the ground-work for the beautifully engraved chromo-lithographed maps of the Dutch Netherlands, and for the reproduction of photographs of Dutch artillery material, by a similar system of engraving upon stone permitting several shades of the same tint to be printed from one stone.*

Photographing on Copper.—A photographic image may also be obtained upon a copper plate by the following method, proposed by M. Mialeret, which may be of use to engravers in giving them an accurate image of their subject to work upon.†

The copper plate, being well cleaned and ready for engraving, is plunged into a solution of

Sulphate of Copper, ...	125 parts.
Sea Salt, ...	75 „
Water, ...	960 „

and allowed to remain for about a minute, it is then taken out of the bath, well washed and polished with a soft cloth. It is next exposed to light for about 5 or 10 minutes under a reversed negative, or even under a paper print on thin paper, care being taken that the design appears reversed on the plate. The plate is then removed from the printing-frame and plunged into a 20 per cent solution of hyposulphite of soda containing a little chloride of silver. After a few seconds the ground whitens, while the design becomes of a deep black. The plate is then taken out and well washed. The black deposit forming the shades may be removed or allowed to remain, in which case the plate should be varnished. It is said that these images may be etched by the use of menstrua which will attack the copper without affecting the silver, but I have not been successful in this application of the process.

XI. Concluding Remarks.

Having now described the different processes most capable of being utilised by the cartographer, it may be as well to briefly sum up the cases in which they are applicable, and to indicate the direction in which improvements should be looked for.

* '*Report on the Cartographic Applications of Photography*,' p. 58.

† '*Photographic News*,' Vol. X, p. 190.

The applications of photography to copying purposes may be divided into two principal classes, according as the original subjects have or have not been specially prepared for photographic reproduction.

As regards subjects in the first class, it is possible to adapt and prepare the original drawings, so as to fit them for the requirements of any photographic process considered most suitable to meet the object in view. As a rule such drawings will be intended for publication or reproduction in large numbers by the photo-mechanical processes rather than by silver or pigment-printing, which will do very well for small numbers.

For the reproduction of maps and plans a process is required which will admit of large-sized sheets being produced. Many processes capable of yielding very beautiful results when employed for subjects of small size are quite unsuited for larger work.

For map-work in line, photozincography will generally be found most suitable and convenient on account of the simplicity of the operations, the facilities it gives for joining several small sections into large sheets, and the short time required for turning out a large number of copies. Under favourable conditions, photozincography will give very excellent results for all practical purposes. If anything finer is required for permanent or standard purposes, then one of the engraving processes would be most suitable, and in certain cases the photocollotype could also be applied with advantage. For diagrams and small maps &c., to be printed with type, photo-typography will prove useful.

For shaded or coloured maps and drawings, photozincography and photo-typography are not applicable, and recourse must be had either to photo-collotype or to one of the engraving methods with bichromate and gelatine which will give gradation of shade, such as Rousselon's, Woodbury's or Geymet's. It is probable that these latter processes will prove of great use as soon as their requirements and capabilities are better known.

It may be as well to repeat that whenever it is possible, drawings specially prepared for reproduction by photography should be drawn on a larger scale than they are ultimately required.

With regard to subjects in the second class, it is evident that the choice of a photographic process must depend very much on the nature of the original subject and its suitability for photographic reproduction by any particular method, as well as on the number of copies required.

It would be impossible to notice here all the cases coming within this class, it will therefore perhaps be sufficient to state that in most instances when only a few copies are required and permanency is not an object, ordinary silver printing will be found most convenient for all classes of subjects; and where the original is sufficiently translucent and photographic cameras not available, both negative and copy may be obtained in this manner sufficiently good for many practical purposes.

If the greatest simplicity in the printing operations is an object, the cyanotype or other iron processes may be used. If the prints are required to be permanent, the simple pigment process or the autotype may be employed, according as the original is in line or shaded.

If a large number of copies are required, then it will be more advisable to employ one of the photo-mechanical processes. The choice will depend much upon the nature and importance of the subject. As a general rule, in cases where the original is a lithograph, engraving or wood-cut, the best effect will be produced by employing an analogous photographic process.

Photolithography or photozincography is generally applicable to all subjects in dot or line, which can be printed in the lithographic press, except very fine delicate engravings or drawings; but if a block is required for printing with type it must be produced by one of the photo-typographic processes. The photo-collotype processes are of more general application and may be used for every kind of subject whether in line or half-tone. Their use is, however, restricted to subjects within the limits of a single negative, and they do not present the same facilities for carrying out alterations and corrections as the lithographic and engraving methods do, and thus their value for reproducing maps &c. on which corrections may be required is very much diminished. The fact of the printing surface being composed of an unstable organic substance like gelatine gives these processes an element of uncertainty which is a great drawback to their extended use on the large scale, especially in hot climates, and a really satisfactory and simple photo-mechanical process capable of reproducing any kind of subject without limit of size within ordinary dimensions is still a desideratum. The photo-engraving methods are the most suitable for high-class work which is likely to repay the cost of the skilled hand-labour required to finish and prepare the plates for the press. A simple method of photo-engraving of general applicability would be most valuable, and it is hoped that such a process will before long be available.

Use of Photography in War.—For the reduction and enlarging of military and topographical sketches, and for multiplying copies of maps and sketches required for use during a campaign, photography can render great services. The principal supply of such maps should, of course, be provided by a permanent office, established in a capital town and well provided with the proper appliances. The extent to which photography can be used in the field will depend on the character of the theatre of operations, available water-supply and means of transport, as well as other military considerations. In an open country with tolerably good roads, a complete photographic equipment might be carried in wagons specially fitted up for the purpose, and arrangements made for copying, enlarging or reducing sketches, maps or plans, and printing them by photozincography or

on a paper specially prepared for photocollotype printing, which would only have to be sensitised when required and, after exposure under the negative, could be fastened down on to a metal plate and printed in an ordinary printing press. In this way also views or other subjects unfit for photozincography might be printed if required in larger numbers than could conveniently be accomplished by silver-printing.

In connexion with such a method of printing by photocollotype, it would be very convenient to arrange for drawings being made on a tissue consisting of a transparent basis, such as waxed paper or sheet gelatine, covered with a thin opaque film which could be easily cut through with an etching-point. Such drawings would form very perfect reversed negatives.

Apparatus and appliances for taking views by the dry and wet processes and for taking prints of them in the ordinary way should also form part of the equipment.

A military photographic travelling field equipment of this kind has been organised in the English service and attached to the Field Train of the Royal Engineers. A description of it was given by Capt. Abney in a paper read before the British Association in 1874.*

In the case of operations in a wild or hilly country, the photographic equipment must be limited to the most indispensable requirements, and be regulated by the nature of the transport available and by other local and military considerations. It is very doubtful whether photozincography could be advantageously carried out in such localities, and the photographic outfit might be limited to some moderate-sized sets of apparatus for views and copying, with a large stock of dry plates and the necessary appliances for silver-printing. Some of the simple iron processes of printing might perhaps be usefully employed. Recent improvements in the preparation of dry plates by what are called the emulsion processes have greatly facilitated and simplified the practice of photography in the field, so far as taking the negatives is concerned, and a sensitive tissue has been prepared by Mr. Warnerke for this purpose, by which the use of glass plates may be dispensed with.

The apparatus, &c., should be strongly packed in moderate-sized parcels so as to be carried either by men or pack-animals.

At the same time it should be stated that it seems very doubtful whether photography can really be employed with much advantage *in the field* under the conditions of modern warfare in civilised countries. Its main use in any case will be the copying of reconnaissances and sketches of positions preparatory to a battle and of sketches and views of positions on the battle-field after the event. The delicate operations required either for taking negatives or for printing copies from them cannot satisfactorily

* '*British Journal of Photography*,' Vol. XXI, p. 415.

be carried out on the move; and therefore the photographic establishment must be more or less stationary, and this may prevent its employment in many cases where it might perhaps be of use. In the Abyssinian Campaign, a staff of photographers from the School of Military Engineering, Chatham, accompanied the force and did good service, under great difficulties, in copying route maps and sketches, and in taking pictures of objects and points of interest. In the Franco-German Campaign in 1870-71, the Germans organised a photographic brigade to accompany the Head Quarters of the army. It was found, however, that the photographers encumbered with apparatus, &c. could not keep up with the movements of the Head Quarters and, indeed, the want of them does not seem to have been very much felt.*

If facilities exist for the transport and working of a small lithographic press, it will be found more convenient to have original sketches drawn with transfer ink for immediate transfer to zinc than to reproduce them by photography, and for this purpose an excellent ink has been devised by Capt. Abney, which may be used on any kind of paper without preliminary preparation. It will also be found a great advantage to print copies of maps on ordinary calico, because it can be folded and packed away much more easily than paper and does not so readily get worn by use. This plan has been adopted in the Surveyor General's Office with success in preparing maps for the Camps of Exercise in this country.

Another use photographic reproduction can be put to in time of war is the preparation of miniature despatches to be sent by pigeon-post. Such despatches were largely used in the Franco-German Campaign for communicating with the beleaguered garrison and residents in Paris. This is a service that photography alone can render and it is likely to be largely utilised in any future European war in similar cases.

* See Capt. Hannot's '*La Photographie dans les Armées*'.