ant as well as the more important features ; hence a reduc­tion is rarely suited for reproduction without intermediate modification, the printing being generally too small to be easily legible, and the mass of minor detail tending to con­fuse the principal sub-lines. The draftsman is therefore called in and the procedure so arranged as to obtain the best results with the least labour. Either he may con­struct a new map by tracing from a silver print of the photograph whatever topographical details are required for it and omitting the rest, or he may ink in such details at once with black ink on a blue print taken from a transfer of the photograph to stone or zinc, in both cases adding names and writing of appropriate sizes ; either result may be reproduced by photography, as the unblackened details of the blue print will disappear in the process. This done, a transfer to stone or zinc may be made from the second photograph for the printing off. Prints from photographic reproductions to full scale exhibit all the blemishes of the hand drawing and somewhat exaggerate them, whereas prints from photo-reductions are freer from blemish, and often as clear and sharp as good hand lithographs. In employing a process of double photography, therefore, the first photo is usually made on a larger scale than that for publication ; the lines of the printing and topographical detail are correspondingly exaggerated by the draftsman ; and then the second photo is a reduction, which should be sharp, clear, and free from blemish.

IX. Map Printing.

Various processes are employed for the reproduction of maps in large numbers for general issue ; some are purely manual, the map being redrawn by hand on copper, stone, or other substance pre­senting a suitable surface from which prints may be taken, or on paper specially prepared for transfer to such substance ; others are carried out with the aid of photography, whereby an exact copy of the original can be obtained either directly upon, or for subsequent transfer to, the surface to be printed from. The former include the processes of copper-plate engraving and lithography, w’hich are the oldest, and still in some respects the best of all, but slow and ex­pensive ; the latter include the processes of photo-lithography, photo-zincography, photo-gravure, and photo-collotype. Engrav­ing on stone is much employed on the Continent for map work, being cheaper and quicker than engraving on copper. Electro- metallurgic processes are frequently employed in connexion with copper-plate engraving, either to protect and harden the surface of the plate with a facing of steel or to furnish duplicates to be printed from, instead of the plate itself being used ; sometimes the wear of the plate is prevented by transferring a print from it to a litho- graphic stone or a zinc plate, from which the printing is done in its stead. By the anastatic process an old print of a map may be transferred to a zinc plate to be printed from.

Engraving may be performed on copper, wood, zinc, or stone ; see vol. viii. p. 435. As done on copper plate for mapping, it is a combination of ploughing with the burin and etching with an acid, the former being used for the names and topographical outlines, the latter for the features of the ground. The system adopted in the Ordnance Survey of Great Britain—where it has been largely em­ployed and carried to great perfection—is as follows. The 6-inch maps of the survey are engraved on copper plates measuring 36 by 24 inches within the marginal lines and weighing about 35 ft ; the 1-inch maps are 18 by 12 for England and 24 by 18 for Scotland. The corners of the maps, the prescribed marginal subdivisions, and the trigonometrical points are first marked on the plate by a scoring machine, in which it is laid, and which is provided with a travelling carriage holding a steel pricker. The carriage is moved along a graduated scale and the pricker along another scale at right angles to the former, and all points of which the rectangular coordinates are known are laid off by vernier-read measurements from the two scales. The plate is then removed from the scoring machine, heated, and given a thin coating of white wax, to form a surface on which the topographical details are plotted before the graving is com­menced. This surface is divided into a number of rectangles by fine lines joining marginal subdivisions, the distances between which are usually so regulated as to introduce sixteen of the survey sheets on the 1/2500 scale into one sheet on the 6-inch scale. The reductions to this scale are made by photography, and the subsequent reduc­tions to the 1-inch scale either by the pantagraph or by photography. Tracings of the reductions in lamp-black, made to fit into the rect­angles, are transferred to the wax ground by nibbing with a steel burnisher. The plate is then ready to be placed in the hands of the

engravers, who complete first the outlines, then the printing and writing, and afterwards the ornament, each class of work being usually done by a different person. The figures of latitudes, longi­tudes, and altitudes, and various conventional symbols, are stamped with steel punches. Parks and sands are ruled with a dotting wheel, and buildings shaded in lines with a ruling machine. When a plate of the 1-inch map is being engraved, all the printing is completed, and line-engraving with the exception of the contour lines, and then an electrotype duplicate of the plate is taken. The contour-lines are engraved on the duplicate, and the hills arc etched on the original plate ; thus two editions of the map are obtained, one with contours but without hills, the other with hills but without contours, the topographical details and writing being the same in both. In etch­ing, the surface of the plate is thinly coated with an acid-resisting substance composed of asphalt, Burgundy pitch, and virgin wax, forming an etching ground, on which the outlines of the hill features are traced, and then marked through with a needle which removes the ground where it passes, exposing the surface of the copper. Aquafortis is applied to bite in the finer lines and then poured off ; the parts which are bitten sufficiently are painted over with “ stop­ping varnish and acid is again applied. The processes of stopping out and biting in are alternately repeated until all the required tints from the lightest to the darkest are produced. In printing from a copper plate, a much more powerful press has to be used than in printing from stone or zinc, as the ink lies in the furrows that have been ploughed or bitten into the plate and not on its surface ; the process of printing is also much slower. In engraving on stone or zinc, the surface is coated with a preparation of gum and lamp-black, and on it the detail is traced with red chalk and afterwards cut in with very fine steel or diamond points so as just to lay bare the surface of the ground without penetrating to any depth, as in copper­plate engraving. A little oil having been rubbed over the surface, the gummy composition is washed away and printing-ink applied ; the printing is performed almost exactly in the same way as in ordinary lithography, except that the printing-ink is in the first in­stance spread over the stone or the zinc plate with a dabber instead of a roller.

Electrotyping is employed to conserve work engraved on copper, either by depositing a thin surface of steel over an engraved plate, which enables it to be printed from very much oftener without injury, or by producing a duplicate to be employed in its stead in the printing. In the latter case, a double process is gone through : first, a cast or matrix is produced in relief by the deposition of copper on the surface of the original plate, and then an intaglio of the matrix—which is therefore a duplicate of the original—is formed by depositing copper on the surface of the matrix. For details of these processes, see Electro-Metallurgy, vol. viii. p. 114. In the Ordnance Survey electrotyping was first employed to obtain duplicates on which to make the corrections and additions neces­sary to show the growth of railroads and towns since the time of the original survey. The alterations are effected more easily when obsolete details are scraped off the electrotype matrix than when they are scooped out of an intaglio ; the original plate is also preserved intact.@@1 Electrotyping is further serviceable in producing the two editions of the general map, one with contour lines, the other with hill-shading, already mentioned, as well as editions for geological and other details. It is also serviceable in effecting a combination of portions of several plates : matrices of the different portions are riveted together to form a single plate ; then an intaglio of this plate is taken, on which any details lost at the junction of the matrices are made good by hand. The dimensions of a full-sized plate are 381/2 by 261/2 inches ; the weight of a matrix is 18 lb, and of the duplicate 38 lb.

There are two essentially distinct processes of lithography,—one in which the map is wholly drawn by hand on the stone, the other, a much quicker but coarser process, in which it is traced with greasy ink on specially prepared paper, which is then laid face downwards on the stone. When lithographs are to be produced by a single print­ing, all hill features, as well as topographical outlines and names, are drawn with a pen or fine camel-hair brush in ink of one colour. Double printing is necessary when the hills are drawn in chalk, two stones being required, one for the chalk work, the other for the pen- and-ink work ; and in chromo-lithography a separate stone is re­quired for the work in each colour. For full details, see Litho­graphy, vol. xiv. p. 699.

Zincography has of late years largely taken the place of litho­graphy for printing from hand-drawn transfers, though not for hand-drawing on the surface of the zinc, as on stone and copper. Zinc plates are less costly and bulky than lithographic stones, and are much more conveniently handled : thus a plate measuring about 43 by 281/2 inches and 3/16 of an inch thick weighs 60 ft, is easily carried by one man, and costs 16 shillings ; a lithographic stone of the same surface is 41/2 inches thick, weighs 450 ft, requires four men

@@@1 In the French and Austrian surveys corrections are made on fresh copper deposited by electricity over the faulty parts, which are scooped out.