by a horizontal plane, contour lines indicate the markings which would be made by the successive risings of a flood to different levels above the sea; vertical hachures indicate the directions which the particles of a volume of water, equally disseminated over the top of a hill, would naturally take in running down the sides and slopes. The most perfect representation of ground is obtained when the shade lines, whether horizontal or vertical, are sufficiently close and well graduated in tone and intensity to imitate good mezzotint shading in Indian ink. A good effect may be and is frequently produced by assuming light to fall on the hills obliquely from a specific direction, illumi­nating them on one side and throwing the reverse slopes into shadow. But this has the disadvantage of giving similar slopes different intensities of shade according to their position with reference to the assumed direction of the light ; on the other hand, vertical lighting, which gives the same intensity to the same slope wherever situated, fails in relief and perspicacity. A commission of citizens appointed by the republican Government of France in 1803 to formulate rules on the subject of topography, con­demned the representation of hills in demi-perspective as absurd, but approved the system of oblique side-light ; it also condemned contours, except for engineering works, and recommended vertical hachures, under the idea that the slope lines of the fall of water represent a material effect of which the eye is witness every moment, and recalls the general cause, if not of the formation, at least of the figure and characteristics, of the mountains.

*Scale of Shade.—*For military purposes it is very desir­able that maps should be so drawn as to enable the angles of inclination of all slopes to be readily ascertained, with a view to determining what portions of the ground are suited for the manœuvres of each of the three arms,—infan­try, cavalry, and artillery. Thus military topographers of different nationalities have proposed a variety of scales to regulate the thickness and distance apart of the shade lines, and generally the proportion of black to white, for different angles of slope, that the map may convey to the mind as accurate a knowledge of the slopes of the ground as of the horizontal outlines. All slopes, however, are not of equal practical importance, but only those which are of most common occurrence and most liable to be gone over by men and horses and wheeled vehicles, and their inclina­tion rarely exceeds 25° ; consequently it is of most import­ance to be able to distinguish variations of slope below that angle : it is occasionally desirable to know the sharper slopes up to 45° or 50°, but greater inclinations are com­paratively of rare occurrence and unimportant. Now in a true scale of shade the intensity increases with the in­clination from 0° to 90°; thus, putting black + white = 1, the proportion of black to white for any inclination *i* by a scale of cosines will be black = 1 — cos *i,* white = cos *i.* But that scale does not sufficiently accentuate the lower in­clinations, which are the most important, and have there­fore to be dealt with more emphatically; this has led to the introduction of a variety of conventional scales, each with the special characteristics which commended themselves to its author. Major Lehmann of the German army supposed light to be admitted in parallel vertical rays and gave the horizontal plane the fullest light, because the reflected coincides with the vertical ray ; at an inclination of 45° the reflected ray is perfectly horizontal, and this slope was therefore least illumined. Disregarding all greater slopes, he placed 45° at the head of his scale and represented it by absolute black ; the scale was divided into nine equal parts of 5° each, from 0° to 45°, up to which the illumination varies inversely as the angle of inclination. General van Gorkum of the Netherlands army improved on Lehmann’s system : he adopted certain groups of contours

arranged according to the slope, making the vertical distances between the contours equal in each group but greater in the higher groups, and between the contours he drew vertical hachures the lengths of which showed by reference to a scale the angles of slope. His lowest group included all angles up to 25°, the vertical distance between the contours being so regulated with reference to the scale of the map as to permit the draftsman to represent the slopes without inconveniently long hachures. For higher angles he doubled and trebled the vertical interval of his contours and the thickness of his hachures. Thus the relative altitudes of any required points might be deduced with comparative facility by noting the thickness and counting the number of the vertical hachures between them. In this respect the system satisfies the require­ments of a military map, but the effect is unpleasing and unsuggestive of hill forms. In 1828 a second French com­mission, having Laplace for its president, was appointed to report on topographical drawing. It reversed the decision of the first commission in favour of oblique side light, as being difficult to execute and inaccurate in giving different intensities to the same angles of slope facing differently ; and, after trying various scales of shade, it determined to increase the intensity in proportion to the sines of double the angles of inclination diminished by 1/15, which gives a more rapid increase of shade for the gentle than the steep slopes. In subsequent instructions of the “depot de la guerre” the proportion of black to white is fixed at one and a half times the angle of slope. In England various scales of shade have been proposed, by Colonel Scott and Captain Webber of the Royal Engineers, and by the Council of Military Education. Colonel Scott’s scale is interesting as having been derived from the average of measurements taken from the best examples of hill sketch­ing in the Ordnance and other surveys, whereas all the others were deduced from a conventional application of geometrical principles. The following table (III.) gives the several scales :—

Table showing the Proportion of Black to White on any Unit of Area, in Horizontal Plan.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Angle  of  Slope. | Scale of Cosines. | | Major  Lehmann. | | First  French. | | Second  French. | | Colonel  Scott. | | Captain  Webber. | | Council of Mili­tary Edu­cation. | |
|  | B. | w. | B. | W. | B. | W. | B. | W. | B. | W. | B. | W. | B. | W. |
| 90° | 1·000 | ·ooo |  |  |  |  |  |  |  |  |  |  |  |  |
| 45° | ·293 | ·707 | 1·000 ·000 | | ·600 | ·400 | ·675 | ·325 | ·708 | ·292 | ·803 | ·197 |  |  |
| 35° | ∙181 | ·819 | ·780 | ·000 | ·512 | ·488 | ·425 | ·575 |  |  | ·724 | ·270 | ·640 | ·360 |
| 25° | ·094 | ·906 | ·560 | ·440 | ·380 | ·620 | ·375 | ·625 | ·339 | ·661 | ·550 | ·450 | ·457 | ·543 |
| 20° | ·060 | ·940 | ·450 | ·550 | ·350 | ·650 | ·300 | ·700 | ·255 | ·745 | ·455 | ·545 | ·333 | ·667 |
| 15° | ·034 | ·966 | ·340 | ·660 | ·286 | ·714 | ·225 | ·775 | ·189 | ·811 | ·338 | ·662 | ·254 | ·746 |
| 10° | ·015 | ·985 | ·230 | ·770 | ·209 | ·791 | ·150 | ·850 | ·126 | ·874 | ·250 | ·750 | ·160 | ·840 |
| 7° | ·007 | ·993 | ·155 | ∙845 | ·155 | ·845 | ·105 | ·895 | ·083 | ·917 | ·173 | ·827 |  |  |
| 5° | ·004 | ·996 | ·120 | ∙880 | ·110 | ·890 | ·075 | ·925 | ·055 | ·945 | ·108 | ·892 | ·082 | ·918 |
| 4° | ·002 | ·998 | ·077 | 923 | ·095 | ·905 | ·060 | ·940 | ·049 | ·951 | ·065 | ·935 |  |  |
| 3° | ·001 | ·999 | ·066 | ·934 | ·073 | ·927 | ·045 | ·955 | ·038 | ·962 | ·033 | ·967 | ·047 | ·953 |
| 2° | ·001 | ·999 | ·044 | ·956 | ·050 | ·950 | ·030 | ·970 | ·025 | ·975 | ·014 | ·9S6 | ·025 | ·975 |

Of late years the system of shading by lines has been abandoned for the English army, and a method of repre­senting slopes by mezzotint shading over a few governing contour lines, laid down by actual survey, has been intro­duced instead. The effect aimed at is a transparent shade, dark in proportion to the steepness of the ground represented ; its object is to give body and expression to the contours and to explain and develop minor features of the ground which may lie between them. This style of shading, being distinct from all line drawing, may be applied over the most crowded details without causing confusion, such as would be produced by hachure shad­ing. The contours are indicated by continuous red lines of constant thickness, strong enough to be everywhere visible through the shading, which is effected by applying lead with a soft pencil over the parts where it is wanted, and then rubbing it in firmly with a piece of chamois