once become a cutting tool. But its bevelled face would rub and grind on the surface of the work, producing friction and heat, and interfering with the penetrative action of the cutting edge. On the other hand, if *C* were tilted forwards as at *E* its action would approximate to that of a scrape for the time being. But the high angle of the hinder bevelled face would not afford adequate support to the cutting edge, and the latter would therefore become worn off almost instantly, precisely as that of a razor or wood-working chisel would crumble away if operated on hard metal. It is obvious therefore that the correct form for a cutting tool must depend upon a due balance being maintained between the angle of the front and of the bottom faces—“ front ” or “ top rake,” and “bottom rake” or “clearance”—considered in regard to their *method of presentation* to the work. . Since, too, all tools used in machines are held rigidly in one position, differing in this respect from, hand- operated tools, it follows that a constant angle should be given to instruments which are used for operating on a given kind of metal or alloy. It does not matter whether a tool is driven in a lathe, or a planing machine, or a sharper or a slotter; whether it is cutting on external or internal surfaces, it is always maintained in a direction perpendicularly to the point of application as in fig. 1, *F, G, H,* planing, turning and boring respectively. It is consistent with reason and with fact that the softer and more fibrous the metal the keener must be the formation of the tool, and that, conversely, the harder and more crystalline the metal the more obtuse must be the cutting angles, as in the extremes of the razor and the tools for cutting iron and steel already instanced. The three figures *J, K, L* show tools suitably formed for wrought iron and mild steel, for cast iron and cast steel, and for brass respectively. Cast iron and cast steel could not be cut properly with the first, nor wrought iron and fibrous steel with the second, nor either with the third. The angles given are those which accord best with general practice, but they are not constant, being varied by conditions, especially by lubrication and rigidity of fastenings. The profiles of the first and second tools are given mainly with the view of having material for grinding away, without the need for frequent reforging. But there are many tools which are formed quite differently when used in tool-holders and in turrets, though the same essential principles of angle are observed.

The *angle of clearance,* or *relief, a,* in fig. 1, is an important detail of a cutting tool. It is of greater importance than an exact angle of top rake. But, given some sufficient angle of clearance, its exact amount is not of much moment. Neither need it be uniform for a given cutting edge. It may vary from say 3° to 10°, or even 20°, and under good conditions little or no practical differences will result. Actually it need never vary much from 5° to 7°. The object in giving a clearance angle is simply to prevent friction between the non-cutting face immediately adjacent to the edge and the surface, of the work. The limit to this clearance is that at which insufficient support is afforded to the cutting edge. These are the two facts, which if fulfilled permit of a considerable range in clear­ance angle. The softer the metal being cut the greater can be the dearance ; the harder the material the less clearance is permissible because the edge requires greater *support.*

*The front,* or *top rake, b* in fig. 1, is the angle or slope of the front, or top face, of the tool; it is varied mainly according as materials are crystalline or fibrous. In the turnings and cuttings taken off the more crystalline metals and alloys, the broken appearance of the chips is distinguished from the shavings removed from the fibrous materials. This is a feature which always distinguishes cast iron and unannealed cast steel from mild steel, high carbon steel from that low in carbon, and cast iron from wrought iron. It indicates too that extra work is put on the tool in breaking up the chips, following immediately on their severance, and when the comminu­tions are very small they indicate insufficient top rake. This is a result that turners try to avoid when possible, or at least to minimize. Now the greater the slope of the top rake the more easiIy will the cuttings come away, with the minimum of break in the crystalline materials and absolutely unbroken over lengths of many feet in the fibrous ones. The breaking up, or the continuity of the cuttings, therefore affords an indication of the suitability of the amount of top rake to its work. But compromise often has to be made between the ideal and the actual. The amount of top rake has to be limited in the harder metals and alloys in order to secure a *strong tool angle,,*without which tools would lack the endurance required to sustain them through several hours without regrinding.

The *tool angle, c,* is the angle included between top and bottom faces, and its amount, or thickness expressed in degrees, is a measure of the strength and endurance of any tool. At extremes it varies from about 15° to 85° It is traceable in all kinds of tools, having very diverse forms. It is difficult to place some groups in the cutting category; they are on the border-line between cutting and scraping instruments.

*Typical Tools.—*A bare enumeration of the diverse forms in which tools of the chisel type occur is not even possible here. The grouped illustrations (figs. 2 to 6) show some of the types, but it will be understood that each is varied in dimensions, angles and outlines to suit all the varied kinds of metals and alloys and conditions of operation. For, as every tool has to be gripped in a holder of some kind, as a slide-rest, tool-box, turret, tool-holder, box, cross-slide, &c., this often determines the choice of some one form in preference to another. A broad division is that into roughing and finishing