with strength, and well balanced. All four desiderata are met in the main by the use of a suitable steel, properly treated and disposed, but balance is also dependent on the weight and form of the hilt. As regards the effect of disposition, grooving or “ fullering" the flats of the blade reduces weight without impairing strength, and is now very largely adopted.

The operations of manufacture, as carried out at the Royal Small Arms Factory at Enfield, may be described briefly as follows, the weapon being the pattern 1899 cavalry sword, which was slightly curved :—

The steel blank, about 17''×11/4''×1/2'', is heated and drawn out to about double its length under a mechanical hammer; it is then reheated and rolled out between rolls suitably shaped, and the fullers formed; the tang (to which the hilt and grips are ultimately attached) is then formed by stamping under a machine hammer, and the blade is cut to length and roughly pointed. The blade, though approximately in its finished form, is now straight; the fins are ground off, the tang annealed, the blade set for grinding, and afterwards rough-ground. It is heated and set to curve in a press, then reheated and hardened by being plunged into a bath of oil kept cool by a water jet. On removal from the bath the blade is dead hard and so brittle that it can be broken by a slight blow, and consequently has to be let down by tempering. This is accom­plished by heating in a bath of molten lead until the steel assumes a particular colour, at which stage, while hot, the blade is adjusted for straightness and curve, this being a delicate operation, as it must be performed while the blade retains its temper and heat before finally cooling. It is now ground to size, and the tang, which, though not hardened purposely, is harder than is desired for machining, is softened by cooling, and machined to the required form. The blade is then ground, reheated to spring temper and set, then tested as follows: When tempered and set before polishing it is fixed in a machine and caused to strike an oak block with a blow of 120 lb with both its edge and back, and with similar blows, but with a force of 60 lb, with both flats. These tests detect flaws, and over or under tempering, by the breakage or distortion of the blade, the blows by the flat being particularly searching tests. If the blade passes the above tests, it is then placed vertically in a machine and shortened 5 in. by bending towards each flat, and must recover perfect straightness; it is then shortened 1 in., and must recover itself when supporting a weight of 35 lb bearing on its tang. This tests the elasticity of the blade. After polishing it is again tested for stiffness as above, and must recover perfect straightness, but only under 32 lb, and for elasticity by a further shortening of 5 in., but towards one flat only.

The introduction of the system described above has greatly simplified and cheapened the process of manufacture, while the greater excellence of the product and the severe and certain tests applied to it by mechanical means have increased the standard of efficiency of the swords in the hands of the troops. It is certainly true that, of old, excellent blades were occasionally turned out by hand, but they were exceedingly costly, and the average merit of sword-blades when turned out in numbers by hand was poor. It must not, however, be supposed that the regular methods described have eliminated 'the necessity for personal skill. The steel can still be spoilt by over- or under­heating, whether for rolling or hardening; tempering and setting require much experience and skill, and blades can be easily injured both in form and temper by unskilful grinding. Sword-making, therefore, though not the somewhat uncertain art it once was, still requires skilled craftsmen for its successful accomplishment.

(H. W. B.; F. Po.)

Authorities.—The following list of works is intended to guide the reader, if desired, to fuller acquaintance with the literature and authorities of the subject :—

*A rchaeology and General History.—*R. Forrer, " Der Werdegang von Dolch und Schwert,” introduction to *Die Schwerter und Schwert­knäufe der Sammlung Carl von Schwerzenbach* (Leipzig, 1905), the best monograph ; Dr Julius Naue, *Die vorrömischen Schwerter aus Kupfer, Bronze und Eisen* (Munich, 1903), with atlas of illustrations, a standard work for the prehistoric periods (neither of these authors has been able to use the Cretan materials) ; R. F. Burton, *The Book of the Sword* (only 1 vol. published; London, 1884); Colonel Lane Fox (afterwards Major-General Pitt-Rivers), *Catalogue of Anthropological Collection, South Kensington Museum* (London, 1874); “Primitive Warfare,” in *Journal* of the Royal United Service Institution (1867, 1868, 1869). For special regions and periods, see Lord Egerton of Tatton, *Indian and Oriental Armour* (London, 1806); Lindenschmit, *Tracht und Bewaffnung des römischen Heeres während der Kaiserzeit* (Brunswick, 1882); Drum­mond and Anderson, *Ancient Scottish Weapons* (Edinburgh and London, 1881). The general treatises and handbooks on arms and armour, such as Grose, Meyrick, Hewitt, Lacombe and Demmin, may be consulted with advantage, but with caution in details. The same may be said of published catalogues of museums and private collections. W. Boeheim *Handbuch der Waffenkunde* (Leipzig, 1900); R. C. Clephan, *The Defensive Armour and the Weapons and Engines of War of Medieval Times and of the Renaissance* (London, 1900); Ashdown, *British and Foreign Arms and Armour* (London, 1909); and G. F. Laking, *The Armour of Windsor Castle* (European section; London, 1904), are trustworthy guides. “ The Forms and History of the Sword,’’ in *Proceedings* of the Royal Institution (1883), by the present writer, reprinted in *Oxford Lectures,* &c. (London, 1890), gives further references and citations on various points.

*Swordsmanship.—*Egerton Castle, *Schools and Masters of Fence from the Middle Ages to the Eighteenth Century* (including a critical bibliography; London, 1892); Carl A. Thimtn, *Bibliography of Fencing and Duelling* (London, 1806). For the beginnings of the art in ltaly, *Flos duellatorum* (a MS. of 1410 edited by Francesco Novati, with critical introduction and notes, Bergamo, 1902). Vigeant, *Bibliographie de l'escrime ancienne et moderne* (Paris, 1882) ; Gomard (assumed name of Possellier), *Théorie de l'escrime* (histori­cal introduction; Paris, 1845). Grisier, *Les Armes et le duel* (preface by A. Dumas; Paris, 1847).

*Technology.—*Wilkinson, *Engines of War* (London, 1841); Latham, “ The Shape of Sword-Blades,” *Journal* of the Royal U.S. Institu­tion (1862); Marcy, *Mémoire sur les armes blanches* (Strassburg, 1841 ; trans, by Lieut.-Colonel Maxwell, London, i860).

For the technique of Japanese swords, see A. Dobrée, “ Japanese Sword Blades,” *Archaeol. Journal,* lxii. I, 218 (London, 1905); as to export of European blades to India, Lord Dillon, “ Arms and Armour Abroad,” ibid. 67, 69-72. (F, Po.)

**SWORDFISH,** the name given to a small family of spiny- rayed fishes (Xiphiïdae), the principal characteristic of which consists in the prolongation of the upper jaw into a long pointed sword-like weapon. The “ sword ” is formed by the coalescence of the intermaxillary and maxillary bones, which possess an extremely hard texture; it has the shape of a much elongated cone, more or less flattened throughout its whole length; the end is sharply pointed. It is smooth above and on the upper part of the sides, and rough below owing to the presence of innumerable rudimentary teeth, which have no function.

The general form of the body is well proportioned, somewhat elongate, and such as is always found in fishes with great power of swimming, as, for instance, in the mackerel and tunny, and the tail terminates in a powerful bilobed caudal fin. A long fin occupies nearly the whole length of the back, whilst the anal fin is generally interrupted in the middle and consequently appears to be double. The skin is very firm, partly naked, partly with small lanceolate scales deeply embedded in the skin. The teeth of the lower jaw are, like those of the upper, merely rudimentary structures, which render the surface of the bone rough without possessing any special function.

Swordfishes have been divided into three generic groups:—

*a. Histiophorus,* with a high dorsal fin which can be spread out like a sail, and with ventral fins which are reduced to a pair of long styliform appendages.

*b. Tetrapturus,* with a dorsal fin of which the anterior rays only are elongate, the remainder of the fin being low or partly obsolete, and with styliform ventral fins as in the preceding genus.

*c. Xiphias,* with the dorsal fin shaped as in *Telrapturus,* but without ventral fins.

Swordfishes are truly pelagic fishes, which either singly or in pairs or in smaller or larger companies ream over the oceans of the tropical and subtropical zones of both hemispheres. Some species wander regularly or stray far into the temperate seas. Some of the tropical forms are the largest of Acanthopterygian fishes, and not exceeded in size by any other Telcostean; such species attain to a length of from 12 to 15 ft., and swords have been preserved more than *3* ft. long and with a diameter of at least 3 in. at the base. The *Histiophori,* which inhabit chiefly the Indo-Pacific Ocean, but occur also in the Atlantic, seem to possess in their high dorsal fin an additional aid for locomotion. During the rapid movements, of the fish this fin is folded down­wards on the back, as it would impede the velocity of progress by the resistance it offers to the water; hut, when the fish is swimming in a leisurely way, it is frequently seen with the fin