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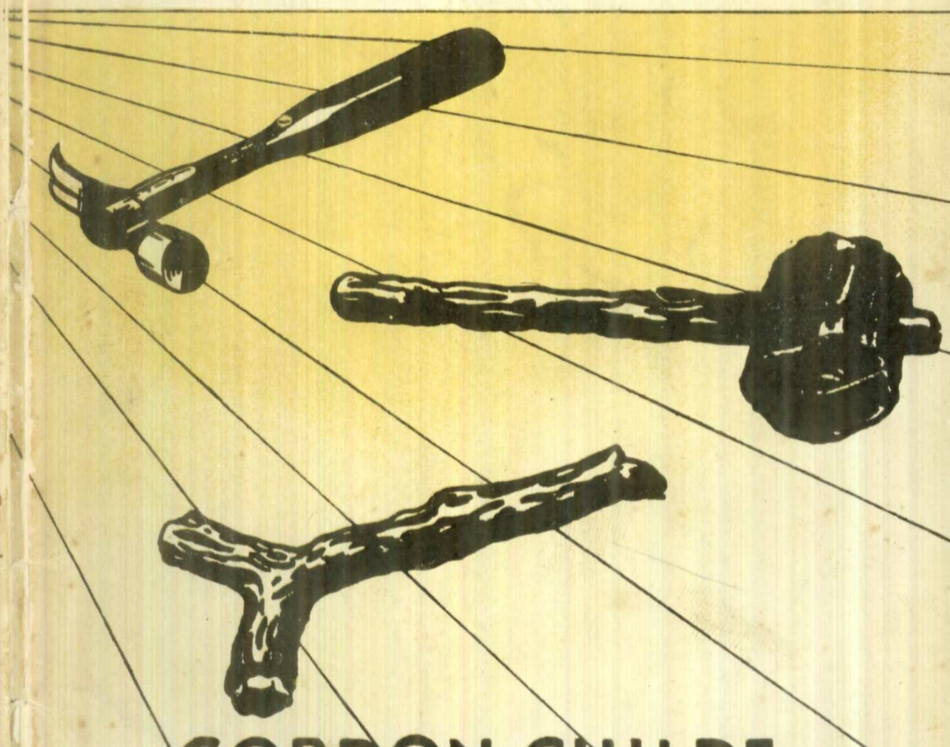
THE STORY OF TOOLS



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STORY OF TOOLS

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Story of Science Series

THE STORY OF TOOLS

by

Professor V. GORDON CHILDE,
D.LITT., D.SC., F.S.A., F.B.A.

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STORY OF TOOLS

BY PROF. GORDON CHILDE.

THE tools you and I use to-day have been developed by a long process of gradual cumulative improvement from much simpler and less efficient implements of wood, stone, bone, bronze, or iron, devised centuries, and sometimes hundreds of centuries ago, by our rude ancestors or ape-like precursors. They still bear the stamp of their remote origin and of the very different social and economic organisations under which they were first made and used. In the course of the long time over which archaeologists can follow the story of tools, men have changed not only their tools but also the whole way in which they got their living (their economy), and consequently the way in which society was organised for co-operation.

Throughout 90 per cent. of human history all societies got their food merely by collecting, hunting or fishing. (The archaeological " ages," *eolithic**, *palaeolithic*† and *mesolithic*§ correspond to this stage, and it is represented to-day by some tribes that Morgan and Engels would call *savages*, like the South African Bushmen and the Australian aborigines). Every available member of a group had to share directly and actively in the job of wresting from nature a bare sufficiency to keep society alive, and all consequently shared in the product. Only about 10,000 years ago (really quite a time !) did some communities begin effectively to augment the food supply by cultivating wheat and other edible plants and/or breeding

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*" Dawn stone " period of the oldest very imperfect stone tools.

†" Old stone " first period of human pre-history in which definite tools are found though none of metal, and generally confined to the geological period termed pleistocene.

§" Middle stone " stage in which tools of the same sort were used and the same economy reigned, but later geologically than the pleistocene, i.e., " recent."

animals for food. (This represents what is termed the *neolithic age** in archaeology and *lower barbarism* to-day). Perhaps 5,000 years later the arts of smelting and casting copper were discovered and some tools were made of bronze instead of stone; iron has not been used for tools for more than 3,000 years. But from the very start men had to have tools in order to be able to live at all.

Men need tools for doing all sorts of necessary things that the remaining animals can do with limbs, teeth or other bodily organs—for instance, for digging to get roots, or shelter from the cold, and for catching prey for food. Men can make tools because their forefeet have turned into hands, because seeing the same object with both eyes they can judge distances very accurately and because a very delicate nervous system and complicated brain enables them to control the movements of hand and arm in precise agreement with and adjustment to what they see with both eyes. But men do not know by any inborn instinct how to make tools nor how to use them; that they must learn by experiment—by trial and error. Fortunately one man can impart to his fellows what he has thus discovered and so save them many fruitless experiments. Most men in fact learn how to use and then to make tools from other members of the human group into which they happen to be born—from society. Any tool is a social product; the rules for making and using it are preserved and handed on by a social tradition. On the other hand just because tools are not parts of our bodies and their use is not instinctive, we can modify them to meet varying conditions and needs. That is how men can live both in the tropics with hippopotami and in the Arctic with polar bears. No animal relying on hereditary bodily "tools," is adaptable to such a range of climates as this!

*"New stone" stage: tools of stone, some sharpened by polishing, but not metal are found and cereals were cultivated and food-animals bred.

The most ancient known men whose fossilized skulls have been dug up in Java (*Pithecanthropos*) and in China (*Sinanthropos* or Pekin man), as well as some rather later races such as Neandertal man (who inhabited Europe about 50,000 years ago), are much more ape-like than any existing variety of man. But they already made tools in the sense that they deliberately shaped pieces of stone to serve their needs. In making tools such creatures exercised and developed the brain. By using tools they were enabled to do without certain bodily peculiarities they shared with apes—for instance, a very massive jaw with projecting canine teeth suitable for fighting or tearing fruit from a bough.

The oldest surviving or *eolithic* tools are made of stone—those used by Pekin man of quartz deliberately collected and carried to his cave. A tiny fraction only were artificially shaped, better to serve Sinanthropic needs. Even these lack any standardised form and might have served many purposes. One feels indeed that on each occasion when a tool was required, a handy piece of stone was adapted to meet the moment's need. So such might be called *occasional tools*.

Very gradually during what is termed the *lower palaeolithic*, more efficient technical processes were discovered for giving to the shapeless lump of stone the required form and especially a cutting edge—bashing the lump on a natural anvil formed by a projecting bit of rock, hammering it first with another stone held in the hand, later with a billet of wood, etc.

Standardized tools emerge. Among the great mass of miscellaneous occasional tools of very varied shapes of lower palaeolithic times two or three forms stand out that occur again and again with very little variation at a vast number of sites in Western Europe, Africa and Southern Asia; their makers have obviously been trying to copy a recognised standard pattern. The collective experience of the group has shown that just this shape is suitable for recurrent jobs and has established a regular method for reducing the shapeless chunk of natural stone to this form. Thus the form and method of manufacture have become standardised and maintained by social tradition; the individual is saved the trouble on each occasion of thinking what sort of tool he wants and how to get it. These oldest standardised tools are all termed "hand-axes" by archaeologists (Fig. 1).* But exactly what they were used for no one knows; they could serve for cutting, digging, scraping, stabbing . . . ; very likely they were really used for all these ends. A hand-axe was a sort of universal tool of all work, an *unspecialised* instrument.

Middle palaeolithic societies, represented in Europe by the Neandertal mammoth-hunters, had learned to manufacture standardised tools of several different shapes, each specialised to a more limited range of uses: in particular triangular flakes with two trimmed edges converging to a point (termed "points") (Fig. 2) could be used as knives but also to tip spears that would pierce the hides of mammoth and rhinoceros (both important items in the Neandertalers' diet), while D-shaped flakes sharpened along the convex edge only (Fig. 3) would be handy for cutting, for scraping skins and similar purposes. Efimenko† suggests that this differentiation reflects a division of labour between the sexes—the "points" would be men's knives used in hunting, the D-scrapers used by women in the preparation of food and clothing (*cf.* Engels' *Origin*, p. 180). Still even middle palaeolithic tools are less varied and technically cruder than those used by the lowest of recent savages—the Tasmanians—just as the Neandertalers themselves were more ape-like than any existing race to-day.

Greater foresight and skill in the manufacture of stone tools, mastery over new material like bone, antler and

*The figures will be found grouped together on pages 29-44.
†Leading Marxist prehistorian in U.S.S.R.

ivory, and a larger variety of specialised tools distinguish the upper palaeolithic phase beginning at least 25,000 years ago. Men now began to provide themselves with a kit of tools not only to satisfy immediate needs, like killing a mammoth or skinning it, but also for making tools or even for making tool-making tools—secondary and even tertiary tools. So they made gravers* of flint strong enough to carve mammoth ivory, flint awls that would pierce bone and antler, fabricators for more delicate flint work, and a variety of specialised knives, scrapers, and choppers. In working flint a new technique, pressure, was invented to thin down flakes by removing shallow scales from both faces. (The operator, instead of hitting the flake with another stone, presses firmly on the edge with a bone or wooden implement like a blunt chisel.) New processes, grinding and polishing, were devised for sharpening bone and ivory and applied to the manufacture not only of weapon-points and needles, but also of wedges and chisels that would split wood. Knives were now provided with wooden handles; indeed, several flint flakes could be mounted end on in the same grooved piece of wood to form the first *composite tools.*

The immediate result and purpose of these specialised secondary and tertiary tools was to provide the huntsman with more efficient weapons and the housewife with better equipment. They were first used to manufacture light but yet penetrating points of flint, ivory or bone to arm throwing spears and darts. Such are the first *missile weapons* that would penetrate the tough hides of large gregarious animals — mammoths, bison, wild oxen and the like. Immense heaps of mammoth bones uncovered in the Ukraine and Moravia show how successfully such could be employed in collective hunts after the great herds that roamed over what was then tundra and steppe.

*An ingenious flint implement with a narrow but resistant edge suitable for engraving.

To increase the range of their missiles and improve their aim some societies soon began to carve spear-throwers of wood, antler or ivory such as are still used by the Australians and the Esquimaux. Others invented a simple bow made of a single piece of pliant wood with a string of gut or sinew and arrows tipped with very delicate flint heads.

Some, rather later, learnt to carve barbed fish-spears out of antler and simple gorges* out of bone. In what is termed in Europe the *mesolithic* phase, after 6000 B.C., we first find proper fish-hooks carved out of a single piece of bone or antler, subsequently improved by the introduction of a barb. About the same time North Europeans made nets of bast, the fibrous bark of the lime, and netting-needles of bone and invented wooden floats and stone sinkers to keep their nets in place.

Thanks to the missile weapons of upper palaeolithic societies combined in favourable circumstance with tackle for catching such fish as salmon, the productivity of the chase was enormously augmented so that population could and did expand and a much smaller area than in lower or middle palaeolithic times would suffice to support a band. Mesolithic societies with bows for fowling and killing small game and with hook and line and net for catching most kinds of fish could even settle down permanently in one place in suitable environments as for instance round the Baltic and in North Russia.

For the housewife bone needles and bodkins (made with graver and borer) permitted the sewing together of skins and even the manufacture of trousers and sleeved jackets, almost certainly a necessary pre-requisite to mammoth-hunting on the palaeolithic steppes and to settled life in North Russia in mesolithic and later times.

So upper palaeolithic and mesolithic tools seem to indicate more clearly that division of labour between the sexes

*A sort of fish-hook that is not hooked, but pointed at both ends, and attached to the line by its middle.

already dimly discerned in the middle palaeolithic. None of those hitherto considered necessarily implies any other division within the group. Theoretically at least, anyone could make a graver or an awl and carve therewith a dart-head or a harpoon. The same remark probably applies to carpenters' tools.

Upper palaeolithic societies in South Russia had been accustomed to split wood with wedges of mammoth ivory or antler driven in with a stone held in the bare hand, or with a hammer of antler or wood in which a tine or branch served as a handle. In mesolithic times pebbles of tough stone were reduced to the shape of the old antler wedges and given a sharp edge by grinding as had been done to the wedges (Fig. 14). Such sharpened pebbles (often termed celts) could be fitted into a handle of wood or antler to serve as axe-heads (Figs. 12 and 13) or adze blades (Fig. 21) for chopping or used bare as wedges or chisels or, if the edge had been hollow-ground, as gouges (Fig. 24). Thus the mesolithic societies of Northern Europe acquired quite an efficient kit of chopping tools. (But note that the axe or adze head was not normally perforated with a hole for the handle as are our axe-heads, but fitted into the handle instead or tied on to it.)

With this equipment they could hollow canoes out of tree-trunks, and even cut short planks and fashion paddles and sledge-runners (some of which have been preserved in peat bogs). Stone tools are quite adequate for this sort of work and might even serve for making rough mortice* and tenon joints. They are too light and brittle for extensive tree-felling, i.e., for clearing virgin forest, and too clumsy to make fish-tail and similar joints for joining up planks. A similar wood-working equipment may have been evolved elsewhere along other lines. It w asin general used by all neolithic societies which in

*A cavity cut into a piece of timber (or stone) to receive the tenon, a projection on another piece made to fit it.

Hither Asia may well be as old as the North European mesolithic, but succeed such in Britain and Denmark.

Though any of the weapons and implements above described might " belong to " the man (or woman) who made and used them—they were even buried with their owner at death—their possession did not confer upon their owner any coercive power over his fellows ; anyone could make them from material accessible to all. Thus there was no room for exploitation and no economic classes. On the contrary co-operation in the use of the implements at least was essential for the survival of the individual and of the group. A single hunter would with this slender armament be no match for a mammoth or a bear. Only by hunting as a pack could Neandertalers for example, support themselves on mammoth meat and bear steaks. The land and all its products were owned by the whole community, and the individual's rights of hunting and fishing were subject to communal regulation. Modern savages thus enforce close seasons for game.

In the *neolithic stage* this sort of primitive communism can still persist. The decisive innovation is the cultivation of food plants, above all cereals, often combined with the breeding of cattle, sheep, goats and/or pigs. Society thus obtained a substantial measure of control over its own food supply, so that population could and did expand. The simplest and probably the oldest form of the neolithic economy is the cultivation of small plots or gardens. Among barbarian tribes in this stage to-day the work of cultivation is always entrusted to the women. This further emphasises the division of labour between the sexes and enhances the economic status of women as long as the produce of their plots is the most reliable source of the community's food. The land is owned communally and generally re-distributed periodically though the produce of individual plots belongs to those who work them (subject usually to well recognised claims by many kinsmen). It is noteworthy that the new tools devised for agricultural

production are hardly ever found in graves as if personal property in them was not admitted. Cultivation did not therefore of itself introduce any class division. But as a man could now produce more than his keep, it might be worth while to keep captives as slaves.

Food-production demanded new tools—for tilling the fields, a *digging stock* (just a pointed stick that may be weighted with a perforated stone) or *hoe*—an antler (Fig. 37) or a crooked stick with a stone blade—(Fig. 21) for reaping a *sickle* (a grooved stick or later an animal's jaw-bone armed with serrated flint flakes stuck in the groove or in the teeth-sockets with the help of some sort of gum) (Fig. 48), flails and winnowing fans* and finally for converting grain into flour a mortar or a *quern*† (Fig. 46) ; till the iron age the quern consisted of a saddle shaped block of tough stone over which a stone rubber was pushed to and fro by the housewife.

Most neolithic societies, like most barbarians to-day, have further begun to make artificial substances that do not occur in nature ; they convert clay into *pottery* by firing it and spin long *threads* out of vegetable fibres or sheep's wool. The potter building up her vessels by hand needs no special tools though her products may be called tools. The spinner requires a *spindle* which, though only a wooden rod balanced with a small stone disc or whorl near one end and twirled by hand, yet uses rotary motion. And to convert the threads into textile fabrics a *loom* was invented—a wooden frame with several movable parts and quite the most complicated mechanism of its day. (In the oldest Egyptian looms the frame was horizontal, in Europe and Asia it was vertical, the warp threads being kept hanging by tying on clay weights (Fig. 62) or by attachment to a movable horizontal bar.) All these operations were normally performed by the women in each

*Fan for separating grain from chaff.
†Hand mill for grinding grain between two stones by pushing the upper to and fro over the lower or by rotating it.

household who not only tilled the fields, ground the grain and cooked the food, but made the requisite domestic pots, spun thread and yarn, wove it into linen or cloth and sewed it into clothes.

Men would hunt and fish, look after cattle if any, clear the plots and build houses and make the requisite simple tools, generally out of local materials. For these operations only one important new tool in addition to those described above was devised. The *bow drill* consists essentially of a wooden spindle rotated by the to-and-fro movement of a bow the string of which is looped round the spindle (Fig. 31). The point may be a flint borer or a core or tube of bone or wood that drives round an abrasive powder, sand (or emery if available). Save for the substitution of a metal point the device remained unchanged till the late middle ages and is still current among many tribes. It will pierce wood, bone, rock and even precious stones like carnelian and turquoise.

To obtain good flint for tools men now sunk shafts and dug galleries in the chalk aided only by antler picks and hoes, chisels and wedges of stone or antler, levers of antler, *shovels* made out of the shoulder-blades of oxen (the anatomical name for shoulder-blade is scapula, the Latin for shovel), and rakes of antler or wood. The communities of flint-miners such as we find on the Downs of England may have been specialists bartering their products for the surplus food produced by peasant villages. We also find " axe factories " where specially good stone is exposed as on Penmaen Mawr that may equally have been manned by specialist families. Apart from such inter-communal specialisation there need be no more specialisation of labour within a neolithic society than in earlier ones.

The introduction of *metal tools* is taken by archaeologists as the beginning of a new era in human history, the *Bronze Age*. And, in fact, the discovery of metallurgy (soon after

4000 B.C. in the Near East) and the tools it provided, exerted a profound influence on the structure of society, in particular handicraft separated off from agriculture. (Engels, p. 185). But as Engels insisted with exceptional perspicacity seventy years ago, copper and bronze did not replace stone tools ; for they were far too expensive. Copper and bronze tools were made by *specialists* or craftsmen who did not grow their own food, and from materials extracted by other specialists and generally transported a long way. Only in the Oriental States where the surplus from irrigation farming was concentrated by despotic monarchs from 3000 B.C., were these metals available in any quantity ; among barbarians they were used almost exclusively for weapons and ornaments.

Metal-workers themselves were perhaps the first specialist craftsmen supported by the foodstuffs others produced owing to their mastery of complicated and baffling processes—mysteries. Naturally they had special tools. The miner who had to quarry the hard rocks in which ores are embedded, had copper gads*, and in Hungary a sort of pick-axe with a shaft-hole (Fig. 20) as to-day, but still relied largely on flint, stone and horn for chisels, wedges and mauls, and for breaking up the ore and driving in the gads used stone hammers (Fig. 8) attached to the handles by thongs fitting in a groove round the head. After 1500 B.C. heavy bronze hammer-heads with a hole for the handle like modern sledge hammers (Fig. 7) (imitating in form wooden mallets) began to replace the stone ones. Skips (or rather trays, for they have no wheels), water troughs, mallets and ladders were carved out of tree-trunks, and leather gloves protected the hand in sliding down a rope into the shaft.

Smelters and smiths needed a blast, but had to be content with catching the wind in hillside clefts or with

*Pointed metal bars like crowbars only generally shorter. Like crowbars but of wood *only* tipped with metal (Fig. 43).

the breath of a team of apprentices each blowing lustily down a blowpipe or a clay-tipped reed till *bellows* were invented about 1500 B.C. The metal was melted in pottery crucibles so thick that they had to be embedded in the furnace and the flame played on them from above. For handling the crucibles green whithies (twigs) were used for a long time, and in all barbarian societies, metal tongs only in civilised States and after 1500 B.C. Moulds were carved out of stone or moulded in clay.

A barbarian village community could not normally support a resident smith; metal ware was generally distributed and manufactured by perambulating smiths travelling from village to village like modern tinkers, as iron-workers still do in Negro Africa. In the Oriental and East Mediterranean cities, however, permanent smiths received supplies of raw material from the State or from State-supervised merchants; for owing to its importance in the armament industry, trade in metal was generally a State monopoly.

For fine work copper and bronze provided new and more efficient tools—saws, axes (still mounted like stone axes (Fig. 17) save in Mesopotamia, Greece and Hungary, where quite modern-looking shaft-hole axes (Fig. 18) were current), adzes, chisels, gouges, drills, nails, compasses, knives, surgical instruments, razors and tweezers, and eventually even small jewellers' hammers and anvils—but not as a rule implements for heavy work such as a woodman's axe. In the Oriental cities the craftsmen using such became specialists too—carpenters, masons, sculptors, seal-engravers, leather-workers, embalmers, jewellers, etc.

But throughout the first fifteen hundred years of the Bronze Age (3000—1500 B.C.), the farmers in rich and highly civilised Egypt, and still more in barbarian Europe, had to work the land exclusively with a neolithic equipment of wood, bone and stone, thereafter supplemented by

some metal sickles; throughout the period sheep were still plucked in default of shears! Nevertheless, well before the oldest Oriental cities were founded, about 3000 B.C., agriculture had been revolutionised by the invention of a *plough* and a yoke. The early ploughs were made entirely of wood and sometimes all in one piece (Fig. 44), and would only scratch the surface of the soil (a plough equipped with mould-board* and coulter† to turn over the sod is first found late in the iron age about 100 B.C. in North-Western Europe, where this device is essential for working the richest soils of the temperate zone.) Not only did the plough enormously augment the productivity of agriculture and initiate the employment of non-human motive power, it also transferred the principal productive activity of society from the females to the males; for cattle-breeding had always been the men's job. Women hoe plots, but men plough fields. (You doubtless could make a plough with stone tools, but, as the distribution of plough agriculture coincides exactly with that of the use of bronze implements, it seems likely that the first ploughs and ox-yokes were carved with metal tools.)

About the same time another craft was taken out of female hands and industrialised. Metal tools enabled the carpenter to execute more accurate and delicate work than had been possible with stone—to make fish-tail and other joints for planks, for instance. The most important consequence was the invention of the *wheel*. Its most obvious application was to transport, converting the clumsy sledge into a wheeled cart or a war-chariot. But on a fast spinning wheel—i.e., a disc of wood, stone or clay fixed horizontally on a vertical axle that can be set in motion by the feet—a man can make in five minutes from a lump of clay what it might take a woman five days to build up by hand. But he must be an expert, a professional.

*The curved plate in a plough which turns over the sod.
†A cutting piece of metal set vertically in front of the ploughshare.

Thus potting became the first mechanised craft. The housewife was thus relieved of one of her chores, but she must henceforth buy her pots with good grain or cloth from the professional potter.

Owing to the comparative simplicity of his machinery and the universal availability of his raw material, clay, the potter could maintain his economic freedom even in an Oriental State.

But the Bronze Age had witnessed the end of primitive communism and the division of society into classes. Among barbarian societies indeed land still remained communal property during the Bronze Age and even later. But cattle may have been passing into individual ownership even in neolithic times. And cattle represented a new sort of wealth that could grow—capital. Then as plough agriculture replaced hoe cultivation, the ownership of plough oxen gave control of another means of production. Wealth in cattle gave their owner the chance of exploiting whoever had none. And with it he could purchase the new weapons of costly bronze and therewith win political power too. For against bronze weapons the stone axes and flint daggers that anyone could make were as useless as the Zulus' spears against European firearms. Even among Bronze Age barbarians we see the rise of an aristocracy, a class of chiefs, monopolising the new weapons.

In the Near East, where agriculture depends upon irrigation, and in the Mediterranean, where it grows not only corn that must be sown every year but also olives and other fruit trees that bear for generations, control of bronze weapons could win control of the land too—the basic means of production. There in the Bronze Age *civilisations* the communal lands became the private estates of kings and nobles. These can extort from the cultivators who have become their tenants or serfs the surplus food requisite to pay for the importation of metal and other raw materials and to support the expert craftsmen who

alone can work them. But these in turn became dependent on king and landowner both for their raw materials and for the sale of their products. In the new class society the craftsmen were relegated to the lower classes with the peasantry (who, as we have seen, reaped little benefit from the new industrial metal). Perhaps that is why no important new tools were invented and no great advances in applied science made in the Bronze Age " civilised " States.

The discovery of an effective method of smelting iron (or perhaps rather the dissemination of a process long discovered but kept secret by a barbarian tribe of Armenian mountaineers) gave opportunities for emancipation. For it made metal cheap and so broke the monopoly of Bronze Age despots. For iron ore, often indeed of very poor quality, is available nearly everywhere, and could be gotten without deep mining in hard rocks. So any peasant community (provided plenty of wood were available as it was NOT in Egypt or Mesopotamia) could spend the slack winter season in smelting iron for themselves (as Swedish peasants did last century). And with it they could forge not only metal axes and agricultural implements, but also weapons with which to challenge the Bronze Age knights and soldiers equipped from the arsenals of Oriental States. And so we find traces of iron smelting (bloomeries) in iron age villages all over Europe and Hither Asia, whereas copper had been smelted only on the rare ore fields and that by specialists and had been distributed by merchants to be finished by other specialists. And so at the beginning of the Iron Age quite a number of old States in Greece, Asia Minor and Palestine, were overthrown and replaced by barbarian societies whose economy still preserved features of primitive communism (for instance, in respect of land tenure).

Cheap metal tools enormously augmented man's control over nature and the productivity of labour. But though the new metal could be produced in most villages, iron working neither arrested the specialisation of handicrafts nor the growth of trade in their raw materials and products. And the chief consumer of metal was, as before, the armament industry. Still iron benefited agriculture and craftsmanship as the costlier bronze could not do.

At the very beginning of the Iron Age, about 1100 B.C., in Palestine the peasants began using agricultural tools of metal—hoes (Figs. 39 and 40), ploughshares (Fig. 45) and sickles (Fig. 50) as well as knives. With cheap iron axes European farmers could seriously tackle the clearing of the forest. With iron gads, crowbars and picks it was practicable to tunnel through hard rock in order to drain swamps in Italy and to convey water to desert soils in Hither Asia. So the cultivable areas were enlarged and the food supply increased. Fairly soon springy iron shears (Fig. 53) were invented for shearing sheep—and used also for barbering and cutting cloth. Before the beginning of our era Roman farmers and sappers possessed in addition iron billhooks of several kinds (Fig. 52), scythes (Fig. 51) with mowers' anvils to sharpen them on in the field (Fig. 59), mattocks*, pickaxes, shovels (Fig. 42), "entrenching tools," like those used in the last war (Fig. 41), forks, and wooden spades cased in iron along the edge.

These advances were due to increasing the productivity of labour by further subdivision of the crafts and the invention of appropriate craft tools so that raw materials, transport and equipment cost less social labour, i.e., became cheaper. The subdivision of the crafts is reflected in the new tools invented ; the smith (Fig. 10) was provided with hinged tongs (Fig. 55), improved bellows, a variety of specialised hammers, chisels, bits and rymers (still worked by the bow-drill) to which were added after 200 B.C. further refinements such as special anvils for nail-making (Fig. 58), drawing blocks for wire, etc. So for the carpenter were devised frame saws (Fig. 35), cross-cut

*A sort of pick-axe with broad instead of pointed ends for loosening soil.

saws, claw hammers and new varieties of axes, adzes, chisels, gouges and borers and about 50 B.C. even planes (Fig. 36) and augers*. By the time the Roman armies added remote Britain to their monstrous Empire in A.D.43, nearly all the manual tools used to-day by smiths, carpenters, masons, bricklayers, shoemakers, barbers, tailors, millers, etc., had been invented. But before this the independent peasant proprietors had been driven off their lands to make way for gangs of slaves or serfs and competition with slave labour had reduced even the free craftsmen to the lower classes again in a new class society.

The first iron tools for agriculture mentioned on page 16, and probably also the first smith's and carpenter's tools subsequently described had been invented in barbarian societies that had occupied the territories of class States of the Bronze Age. But such States still persisted in Assyria, Babylonia, Egypt and elsewhere, and adopted the new metal for imperialist wars. The barbarians for their part made themselves a ruling class in Asia Minor and Persia or at least gave up communal land tenure for private holdings in Palestine, Greece and Italy. War "waged for plunder as a regular industry" increased the power of military leaders who naturally secured the major share in the tribal lands, became hereditary princes and nobles and could maintain their position by purchasing superior weapons made from high grade ores by expert *armourers* (Engels, p. 187). So class societies were quickly re-established over wider areas.

The cleavage into rich and poor was emphasised by coined money, after 700 B.C., which brought in its train mortgages and usury. At the same time the progressive division of labour completed the separation of handicraft from agriculture and left the craftsman producing "commodities," articles for sale not for use. Even the small peasant proprietor who went in for growing, say olives,

*Implement used by carpenters for boring wood.

for the market instead of corn for subsistence was caught in the same net. For all tended to become dependent on the merchants who bought their products and were better provided with the new coins than anyone else (Engels, p. 190), while the continual wars increased the supply of slaves. Successful merchants would invest their profits in slaves and set these to work for them in competition with free craftsmen.

By 400 B.C. the little States of Greece and Italy were dominated by capitalists owning estates worked by slaves or tenants and workshops manned by servile artisans. And when between 200 B.C. and 50 A.D. the Roman Empire swallowed up all the little States and the older States of Africa and Asia, and the barbarian Celts in Western Europe too, it was an empire of usurers and slave-owners. Craftsmen and cultivators alike, whatever their legal status, sank once more into the lower classes.

This economic enslavement had been accelerated after 500 B.C. by the invention of the first labour-saving machines. For these were so costly that unlike the manual tools described above, only States or capitalists could afford to own them.

In the Bronze Age the lintel* stones at our own Stonehenge, weighing 6¾ tons, and the 2,300,000 blocks of the Great Pyramid in Egypt, averaging 2½ tons each, had been dragged into position up laboriously constructed ramps with the aid solely of ropes and wooden levers, rollers and rockers. Even in the Iron Age the Assyrians used no better devices in erecting colossal figures of solid stone in their palaces round Mosul. In all the Egyptian and Assyrian pictures of such operations not oxen but only human tractive power is being used. After 500 B.C. the Greeks invented the pulley, the block and tackle, shears, and the capstan and enlarged pincers into scissors for grasping large masses. By the beginning of our era

*Piece of timber or stone set over a doorway or spanning horizontally the space between any two uprights.

the Greeks and Romans possessed appliances for lifting weights and manoeuvring heavy loads that have only been bettered in the last century. The shears were normally two-legged and kept in position by four stay ropes. The windlass was turned by a crank or in special cases by a treadmill worked, of course, by slaves. Stout timbers for the shears, strong ropes and even iron-bound windlass and capstan were naturally so expensive that they were owned only by public corporations or capitalist contractors and not the workers who operated them.

Even more important for future development were fresh applications of continuous rotary motion, first recognisable in milling. Even in the cities of the Bronze and Iron Ages grain was normally converted to flour in each household. From about 500 B.C. a *rotary quern* began to replace the old push-quern in Mediterranean cities, and later in the villages of the still barbarous Celts north of the Alps. (The Britons got it by 50 B.C., the Germans only after 300 A.D.) The new device consists essentially of two stone discs joined by a central pivot on which the upper stone can be rotated by a wooden handle. The rotary quern lightened domestic labour, but, like the loom in neolithic times, and the sewing machine last century, it remained a domestic appliance, worked by the housewife or her slaves and did not of itself create a new specialised craft as the potter's wheel had done.

But about the same time the baking industry was being mechanised. For though all countryfolk and many townspeople still ground and baked their own flour, in the cities bread and cakes were manufactured for sale on a large scale. From 500 B.C. master bakers began to instal rotary mills, constructed essentially on the same principle as the rotary quern (save that the nether stone is conical, the upper shaped like an hour-glass, the hollow top serving as a hopper*), but considerably larger and driven by a

*Funnel or trough in which something is placed to be fed into a mill.

donkey or horse walking round and round. This was the first application of non-human motive power since the ox had been harnessed to the plough and the cart nearly three thousand years before ! Naturally the large stone mills and the beasts that worked them represented a substantial outlay on the part of the master baker, who thereby became a small capitalist. There were five such mills in a single bakery at Pompeii, a small provincial town.

Similar mills were apparently employed for grinding ore in mines. And another sort of rotary mill, also driven by donkey-power, was employed in the extraction of oil on capitalist olive farms.

Then about 100 B.C. a waterwheel was invented and set to turn flour mills. So at length inanimate motive power was harnessed to human use. It involved gearing too. The large wooden wheel, 10 to 11 ft. in diameter, carried on its circumference at first metal buckets, later wooden vanes, on to which the water flowed. It naturally revolved in the vertical plane. A cogwheel at the other end of the wooden axle engaged a gear-wheel near the lower end of a vertical spindle, also of wood, to the top of which the upper millstone that, of course, revolved in the horizontal plane, was attached by iron staples. The gear-wheel consisted of a pair of wooden discs some 6 in. apart, joined together near their outer edges by six vertical iron bolts that formed the teeth of the gear.

This first application of water power provided the model for all later power mills till the invention of the steam engine. But it was scarcely applied outside the flour milling industry for over a thousand years, and was very little utilised even for corn mills till after A.D. 400, when the Roman Empire was collapsing ! On the contrary, slaves were set to turn similarly geared mills of rather smaller size by cranks or treadmills ! The Romans and Hellenistic Greeks were not lacking in technical skill and had plenty of capital, but they did not invest it in labour-saving machinery till the supply of slave labour from

successful wars began to run short, and by then the market for manufactures was also collapsing.

By reversing its action the wheel just described could be used for raising water to irrigate fields or drain mines.

In the civilised Oriental States of the Bronze Age and the earlier part of the Iron Age the cultivator had had to raise water from the river to the level of the bank in a leather bucket on a rope aided at best only by an ox to pull the rope over a round log or roller or by a long pole balanced on a forked wooden upright that on the lever principle reduced the exertion needed to raise the full bucket. After 100 B.C. irrigation machines were installed in Egypt, now ruled by Greek kings. They probably worked on the principle of the Persian wheel still regularly used in Hither Asia and India to-day. In this, an ox, walking round and round like the donkey in the corn mill, turns a vertical spindle shaft the lower end of which is geared as in the waterwheel to turn the horizontal axle of a large wheel revolving in the vertical plane and carrying buckets on its circumference.

To give a still higher lift the buckets fixed to the edge of the wheel may be replaced by a long iron chain to which the buckets are attached. The Roman writer Vitruvius describes such a machine.

In the narrow galleries of a mine there is no room for an ox to describe circles. The wheels were turned by slaves working a crank or treadmill. In a Spanish mine of Roman date a battery of two pairs of 14 ft. wheels set at different levels gave a total lift of 10 ft. 6 in. ; in another mine no less than 14 wheels (and 28 slaves working day and night) were needed to raise water 150 ft. Another device, the screw (said to have been invented by Archimedes about 300 B.C., and still used in France and in China) gave a lift of 11 ft. Both devices were far less efficient than pumps. What sounds like a quite serviceable pump had apparently been invented as early as 100 B.C., but seems never to have been used for draining mines in antiquity. It came into use for that purpose in Europe only in the "Dark Ages" between A.D. 500 and 1500. Incidentally the principle of the screw was also used for presses, particularly for olives in quite a modern manner—the screws being, of course, of wood, hand-cut in a lathe. The idea was not applied to bolts for fastening things till the Middle Ages. But a screw-thread might be cut on the points of awls and augers to discharge the shavings that would otherwise accumulate in the hole.

But the Greek and Roman mechanics were capable of making fine metal gears—cogwheels, ratchet-and-pinions, etc., at first for locks, subsequently also for clocks driven by water and similar small mechanisms.

In Europe the Roman slave economy collapsed through internal contradictions, and Roman civilisation was overthrown by barbarian invaders about A.D. 400. In the East, in Byzantium (Istanbul) and later in the Arab cities of Hither Asia, North Africa and Spain, the whole classical technical equipment was preserved and even enriched with new tools (e.g., scissors), and machines (e.g., windmills). Even in Europe craftsmen survived to hand on their technical traditions and tools, albeit hampered by shortages of materials. Teutonic tribes (such as the Anglo-Saxons), who then spread over the European provinces of the effete Empire right to Italy itself, had finally dislocated the commercial machinery that had ensured the distribution of raw materials and of craft-products. On the other hand, as Engels shows (p. 177), the very barbarism of the invading Teutons and their gentile constitution went far to rejuvenating Europe. The invaders were indeed far from primitive communism, but they had not yet reached private ownership of land, usury, nor industrial slavery of the Roman patterns. Craftsmen were highly esteemed among them. Rich graves contain the bodies of smiths buried not only with all their tools, but also weapons.

Very soon indeed the conquerors formed territorial class States and abandoned communal ownership of land for the feudal system with its corollary of serfdom for the cultivators. But many craftsmen retained their freedom. After A.D. 1000 a runaway serf could win his freedom if he could reach a town and set up as a craftsman. And the urban artisans, by combining in guilds, were enabled to maintain a degree of economic freedom over against State, landowner, and merchant, that the independent craftsman of the Bronze Age or the Classical Iron Age had never known.

Few important new manual tools were invented, but labour-saving machines were. Waterwheels had been established on feudal estates even in England by A.D. 700. After 1100 water power was set to work pulping mills (1290), hammers in forges (1320), saw mills (1322), bellows for blast furnaces (1295), wire drawing machines (1400), spinning machines, etc. All these machines were made mainly of wood as were even the barrels of pumps. But the teeth of gears were generally made of iron, while more delicate and complicated metallic gears were developed by locksmiths and above all by clock-makers. At the same time the use of water power to produce a blast allowed iron to be cast—hitherto only wrought iron had been used in industry.

The immediate fruits of the new machines were, on the one hand, an enormous increase in the output of commodities (including tools), on the other, the invention of new manual tools for the construction and repair of machines, clocks and, of course, cannon and other weapons. Among those created before 1500 are bolts and nuts, together with the whole family of spanners for tightening and loosening them, the brace* as used to-day, new forms of drill (e.g., for smoothing the wooden barrels of pumps) and lathe. (But pointed screws, "screw-nails," were little

*Curved implement of wood, metal, or both, used for turning boring tools.

used till the 19th century, and so till then screwdrivers and gimlets were less important than they are now.) As metal replaced wood in the construction of machines from the 18th century on, a huge new family of highly specialised tools, too complicated for description here, grew up.

The ultimate fruits of machines have been, however, to dispossess the craftsman of the tools of production and reduce him to wagery. For the costly new machines were not owned by the artisans whose work they performed, but by private individuals. Successful merchants became industrial capitalists by investing their profits in machines, as in Greece and Rome they had invested in slaves ! As commodities produced by manual tools cannot compete on the market with the output of machines, their users were left free either to operate those machines on terms dictated by their owners or to starve ! This is the essential feature of bourgeoise capitalism though the process of its genesis as disclosed by Marx in *Capital* was actually a lot more complicated than this summary can show.

One point remains to be noticed. Mechanisation has proceeded much more slowly in agriculture than in handicraft. Sheep have indeed been shorn by machines on capitalist farms in Australia for the last fifty years, and reapers-and-binders and similar machines have been displacing scythes and hoes more slowly in America and even Britain. But most European peasants and Scottish crofters have been no better equipped than Roman farmers two thousand years ago ! On the collective farms of the U.S.S.R. however, agricultural machines have replaced the old apparatus devised in a slave society, immensely lightening toil and increasing output per head. But these new instruments of production are owned neither by individual farmers nor by private capitalists, but, like the land, by the community as a whole. Hence under the Soviets mechanisation means liberation from toil not to work for a capitalist's profits but for the community in a co-operative effort to raise the standard of life for all.

SUMMARY

The sketches illustrate some of the more important tools, mentioned in their historical order above, to show the descent of those still in use. Fig. 1 is the first standardised but unspecialised tool—the lower palaeolithic hand axe. Figs. 2 and 3, the specialised middle palaeolithic "man's" and "woman's knives." From Fig. 2 descend not only the great family of stabbing *weapons*, but also many double-edged knives. Fig. 3, while primarily designed for scraping, may be regarded as the ancestor of modern knives ; in the upper palaeolithic flint specimen, Fig. 4, the back is blunted by chipping, while Fig. 5 shows the translation of this into metal, much later, in the Bronze Age.

The earliest hammer would be just a round stone held in the bare hand, and such were still used by masons and even sculptors in Egypt and other Bronze Age States. But for breaking up ore and forging, Bronze Age metalworkers cut a groove round the stone and lashed it on to the end of a handle as in Fig. 8. But for lighter blows, a billet of wood was used even in palaeolithic times, and by the Bronze Age this had been improved into a handy mallet. Or a section of tree stem from which a convenient branch projected or of antler with a projecting tine would make a wooden hammer with a natural handle. Later in the Bronze Age the handle was made separate from the head and fitted into a hole in the latter just as in our mallets (Fig. 6). Before the end of the Bronze Age the wooden head had been copied in solid bronze as in Fig. 7 for heavier work. The Greek smith in Fig. 10 has a variety of hammers, all of iron.

In upper palaeolithic times men used to split wood with wedges or chisels of ivory or antler. The wedge might be formed on a tine, cut off obliquely near the tip but not detached from the antler, that could be used as a lever handle after the wedge had been hammered in (Fig. 11).

The bevelled edge of the tine might be replaced by a blade of flint or polished stone (like Fig. 14) inserted into the root of the tine (Fig. 12). This is one way in which an axe for chopping may have arisen. Then the stone axe head might be attached to a wooden shaft either with the aid of a perforated section of antler, or directly into a straight shaft (Fig. 13) or into the split end of a bent wood one like the bronze axe in Fig. 17. Copper and bronze axes at first closely copied stone ones, save that the blade was always somewhat splayed, giving a greater cutting edge (Fig. 15)—this splay was at first the result of hammering the casting to produce a sharp edge, but was later deliberately exaggerated in the mould. They might be hafted into a straight handle just like stone axe-heads. In Europe the bent haft, Fig. 17, was always preferred, and its use ultimately prompted the invention of the " socketed celt " (Fig. 16) about 1200 B.C. It has a tubular hollow cast in the head into which the end of the crooked stick fitted. The same method of hafting was used for bronze gouges (Fig. 25) and chisels (Fig. 28), and continued in use even for iron axes north of the Alps till 400 B.C. But in Hungary, Greece and Hither Asia, copper and bronze axes were provided with a shaft-hole in the head, like modern axes, from 3000 B.C. Besides simple axes like Fig. 18, double-bladed forms were made, especially in Greece and Crete, combinations of axe and adze (Fig. 20, Hungary) and axe and hammer or pick. All these forms might be reproduced in iron after 1000 B.C. and gradually replaced the unperforated forms, the principal subsequent development being the widening of the blade as in the Roman woodman's axe (Fig. 19).

Adze blades may be similar to axe blades, but they are usually assymmetrical (Fig. 22, flint) and must be mounted on the bent handle like Fig. 21 (neolithic Bohemian). In bronze and more often in iron a shaft-hole was made in the blade's butt for the handle in those countries where the shaft-hole axe was used. Chisels are just like the

earlier stone and bronze axe-heads, but considerably narrower (Fig. 23 stone, Fig. 26 bronze). They may be held bare in the hand (or in the Iron Age in tongs) or mounted in horn (Fig. 23) or wooden handles as to-day; to fit into the handle the later Bronze Age (Fig. 27) and Iron Age chisels taper to a tang. Gouges beginning in mesolithic bone tools were made of stone in the neolithic (Fig. 24) and assume a modern form in the Bronze Age (Fig. 30 Mesopotamia, Fig. 25 Ireland).

Needles and awls even to-day preserve the form of the upper palaeolithic bone ones. Boring tools begin with the upper palaeolithic flint awls (Fig. 29) used for perforating bone. Attached to the stock of a bow-drill (Fig. 31) they become bits and when of metal have generally square butts like Fig. 30, which could be used as a hollow-borer as well as a gouge. Centre bits and rymers were first used in the Iron Age about 700 B.C. A screw thread to get rid of the borings was never cut on the point before 400 B.C. The brace did not replace the bow-drill till the middle ages, but by 2500 B.C. Egyptian stone cutters were using a drill-stock with a bent handle weighted with stones to produce the downward pressure given in the brace with the left hand (Fig. 32). Augers with a T handle like ours were sometimes used in Roman times.

Serrated flints like Fig. 33 were used for sawing through bone by upper palaeolithic hunters and later but blades long enough to serve as carpenters' saws were impossible till metallurgy was discovered. Bronze Age saws are all of the type shown in Fig. 34, and the teeth are not raked in one direction; frame saws (Fig. 35) and cross-cut saws were invented early in the Iron Age before 500 B.C. and generally have raked teeth though usually still set all in one plane. In the Bronze Age wood was dressed with adzes, but a plane (Fig. 36) had been invented by 50 A.D.

For tilling plots and digging a straight stick, the brow tine of a red deer's antler (Fig. 37) or a hooked stick, to which a stone blade might be lashed as in Fig. 21, were used by neolithic peasants and even in the Bronze Age Egyptian farmers used wooden hoes like Fig. 38. But from the beginning of the Iron Age in Palestine hoes were shod with metal blades (Figs. 39 and 40). Figs. 41 and 42 are Roman digging tools. Fig. 44 is an unusually clumsy sort of plough from a German peat bog. But all Bronze Age ploughs agreed with it in being made of wood alone; only in the Iron Age were they shod with metal shares like Fig. 45. Neolithic and Bronze Age sickles were usually made of serrated flints mounted as shown in Fig. 48, which in the later Bronze Age were sometimes copied in metal (Fig. 49) and regularly in the Iron Age (Palestine); Figs. 50 and 51 show Roman sickle and scythe, Fig. 52 a Roman billhook. Fig. 53 is the earliest sort of shears found in Europe about 250 B.C., while Fig. 54 is Roman. Fig. 55 represents early Iron Age tongs, Fig. 57 a very small bronze anvil for fine metal work from the British Bronze Age, Fig. 58 a nail-makers, and Fig. 59 a mower's anvil from Roman France, and Figs. 60 and 61 Roman trowels.

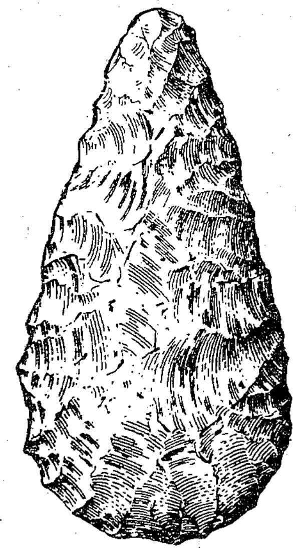


FIG. 1

FIG. 1A

Hand axe 1 : 2

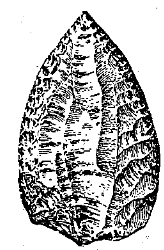


FIG. 2

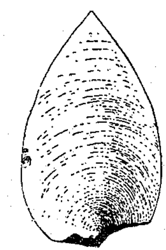


FIG. 2A

Mousterian point 1 : 2

KNIVES

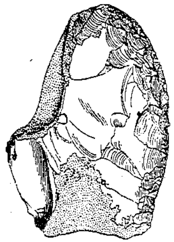


FIG. 3

Mousterian scraper (knife) 1 : 4

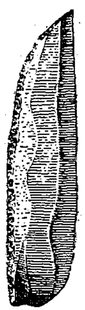


FIG. 4

Upper Palaeolithic knife 1 : 4

FIG. 5

Bronze knife 1 : 3

HAMMERS

FIG. 6

Wooden mallet 1 : 8

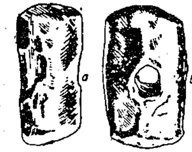


FIG. 7

Bronze hammer head 1 : 6

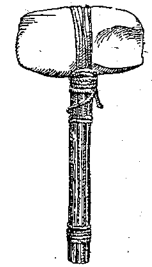


FIG. 8

FIG. 9

Stone hammers 1 : 6

FIG. 10

A Greek Smithy about 500 B.C.

AXES

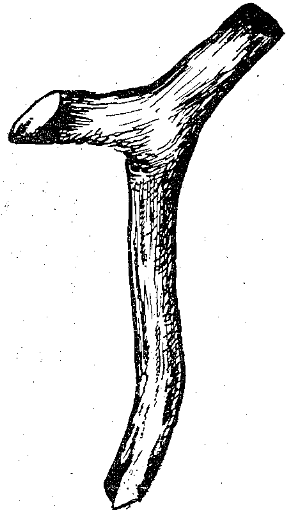


FIG. 11
Adze of reindeer antler
1 : 7

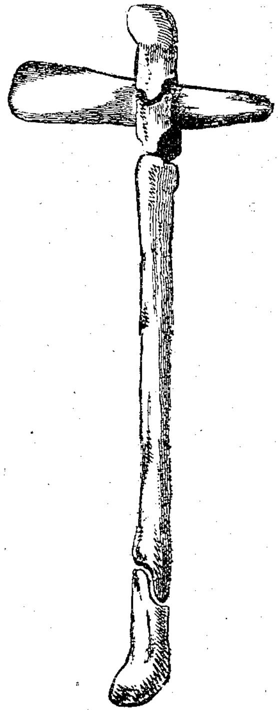


FIG. 13

Stone axe in handle 1 : 7

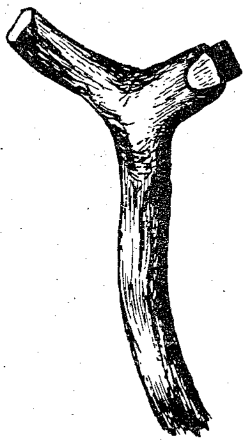


FIG. 12
Stone axe in handle of reindeer antler 1 : 7

AXE HEADS

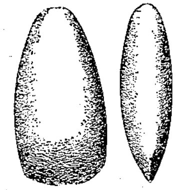


FIG. 14
Stone axe 1 : 4

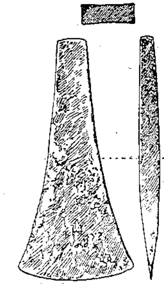


FIG. 15 Bronze flat axe 1 : 4

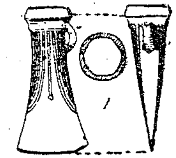


FIG. 16
Bronze socketed axe 1 : 4

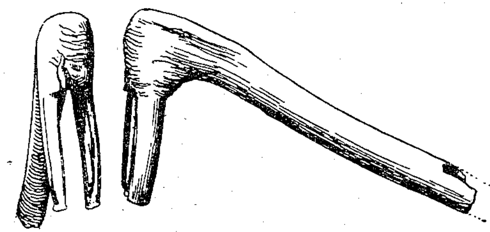


FIG. 17
Handle for bronze axe 1 : 4

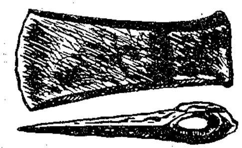


FIG. 18
Bronze axe head 1 : 4

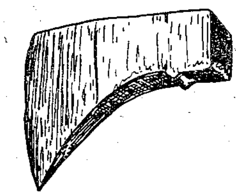


FIG. 19
Iron axe head 1 : 4

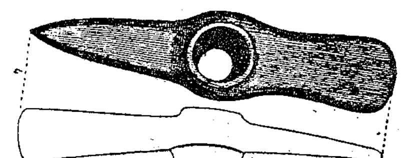


FIG. 20
Copper axe adze 1 : 4

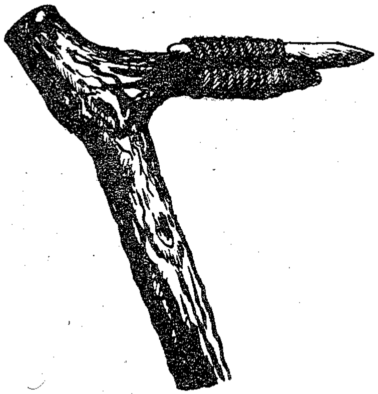


FIG. 21
Stone adze mounted 1 : 4

FIG. 23
Stone chisel 1 : 2

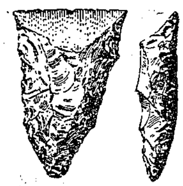


FIG. 22
Flint adze 1 : 4

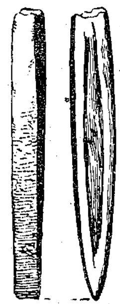
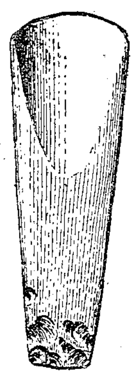
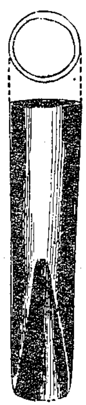


FIG. 26
Bronze chisel 1 : 2



Flint gouge 1 : 2

FIG. 24



Bronze gouge 1 : 2

FIG. 25

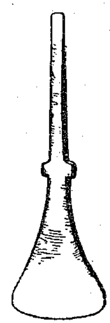


FIG. 27
Bronze chisel 1 : 2

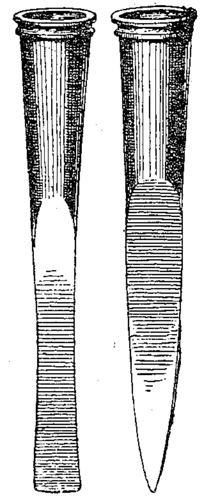


FIG. 28
Bronze chisel 1 : 2

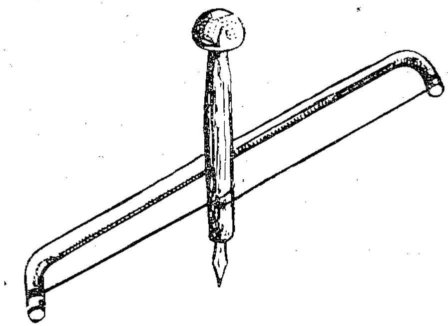


FIG. 31
Bow drill (reconstructed)

FIG. 29
Flint borer 1 : 1

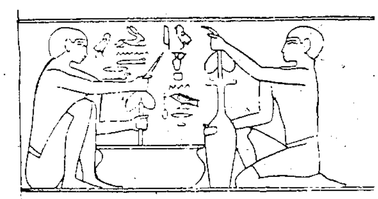


FIG. 32
Boring vases in Egypt about 2500 B.C.

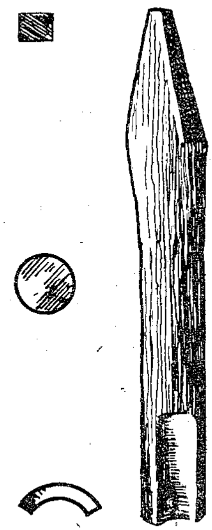


FIG. 30
Copper bit 1 : 1

CARPENTER'S TOOLS

FIG. 33 Flint saw 1 : 1

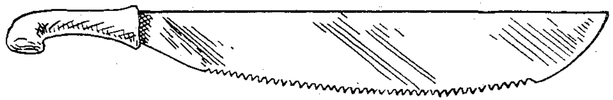


FIG. 34 Egyptian Bronze saw 1 : 4

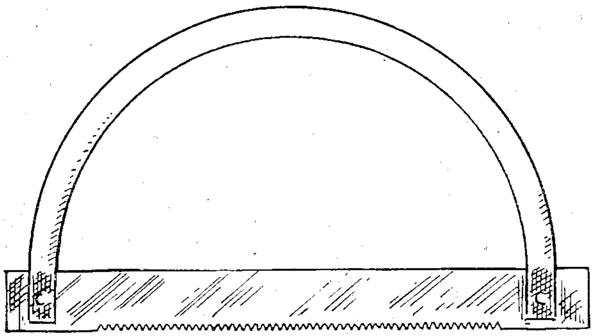
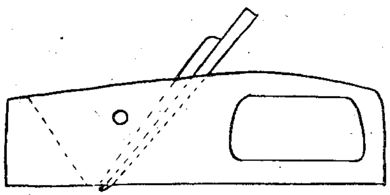


FIG. 35 Roman frame saw 1 : 6



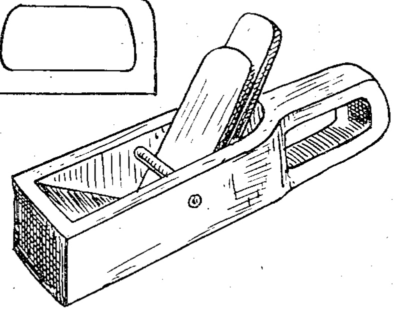


FIG. 36
Roman plane 1 : 4

DIGGING TOOLS

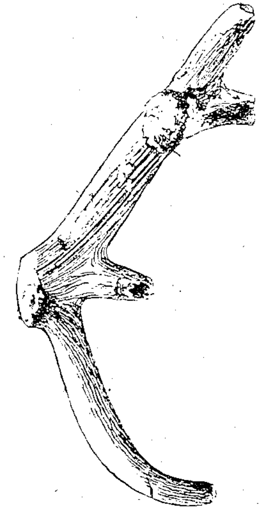


FIG. 37
Antler pick 1 : 4

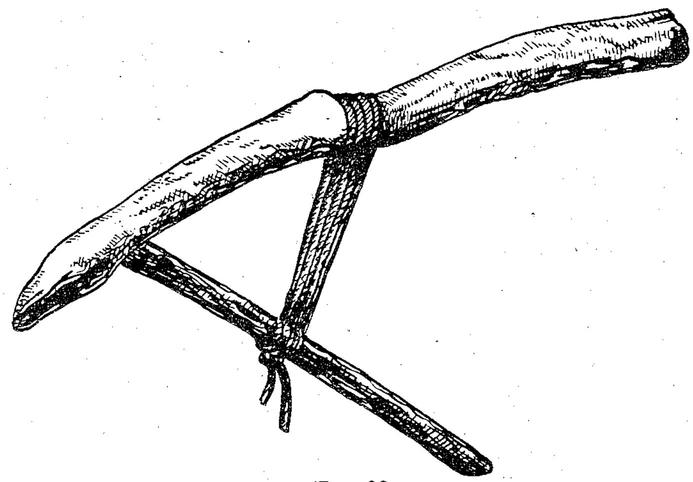


FIG. 38
Wooden hoe, Egypt 2500 B.C. 1 : 4

DIGGING TOOLS

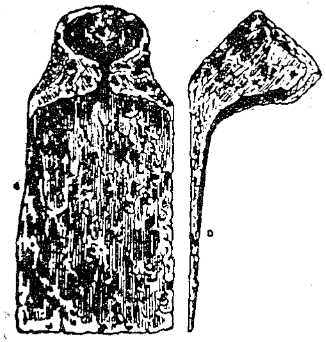


FIG. 39

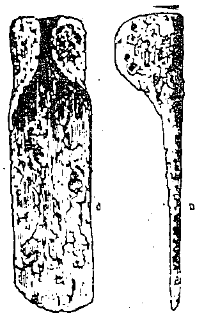


FIG. 40

Iron hoe blades 1 : 4

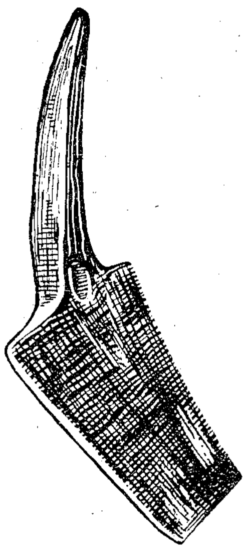


FIG. 41
Roman digging tool iron 1 : 3

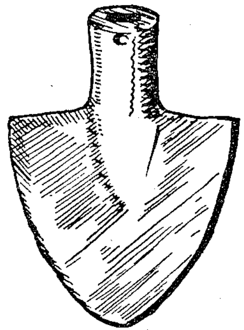


FIG. 42
Roman spade iron 1 : 3

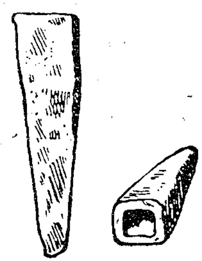


FIG. 43
Bronze gad tips 1 : 4

AGRICULTURAL IMPLEMENTS

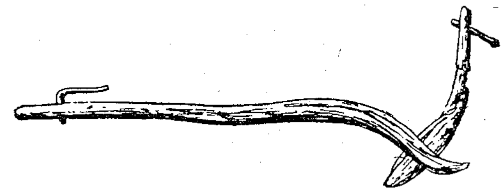


FIG. 44

Wooden plough

FIG. 45

Iron ploughshare 1 : 4

FIG. 46

Grinding corn on a saddle quern

FIG. 47
Flint sickle blade 1 : 1

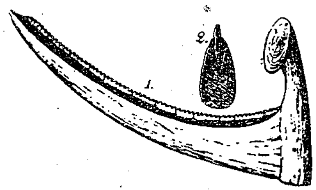


FIG. 48
Egyptian flint armed sickle 1 : 4

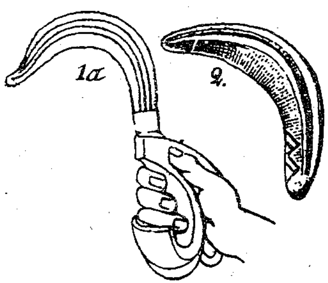


FIG. 49
Bronze sickles 1 : 4

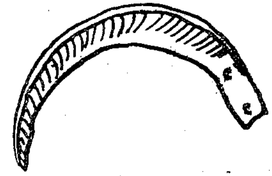


FIG. 50
Iron sickle 1 : 4

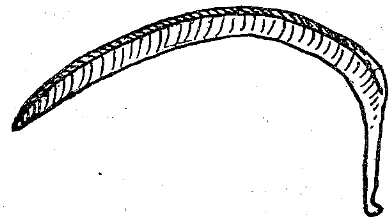


FIG. 51
Roman scythe 1 : 4

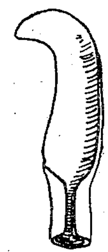


FIG. 52
Roman billhook 1 : 4

SHEARS & TONGS

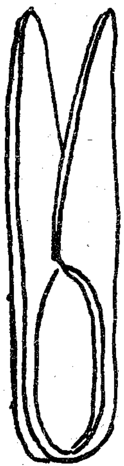


FIG. 53

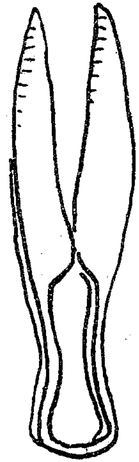


FIG. 54

Shears 1 : 3

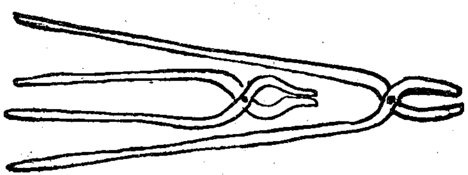


FIG. 55

Tongs, iron 1 : 6

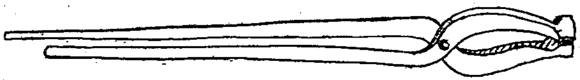


FIG. 56

Roman tongs 1 : 8

ANVILS

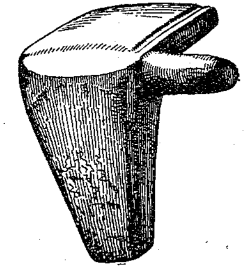


FIG. 57
Bronze embosser's anvil 1 : 2

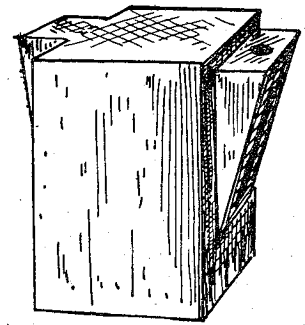


FIG. 58
Nail heading anvil, Roman 1 : 2

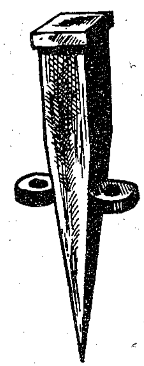


FIG. 59
Mower's anvil, Roman 1 : 2

FIG. 60

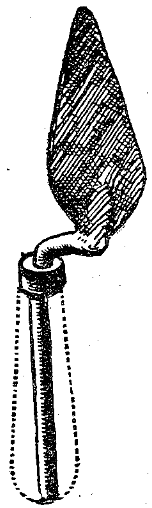


FIG. 61

Roman trowels 1 : 4

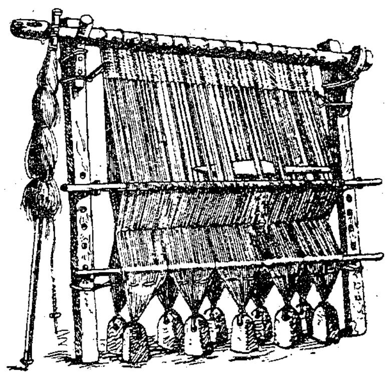


FIG. 62

Vertical loom (reconstructed)