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# UNITED STATES PATENT OFFICE

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## PRODUCTION OF ALLOYS CAPABLE OF BEING FORGED AND HARDENED

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The fundamental composition of a high speed steel has remained unaltered since its evolution.

0.6–0.9% C, 12–20% Wo, 3–6% Cr, balance iron with the usual impurities. Latterly, in addition to the above ingredients, up to 2% V and 2–5% Co are added. Yet with all modifications the carbon content remained unaltered if indeed it had not been increased for special purposes (riffeled steel). In this connection the carbon content has always been considered a necessary condition for the hardening of the steel, the high degree of hardness being obtained immediately after quenching from high temperatures.

According to the invention, however, one succeeds in producing alloys of the high speed steel type which in their behaviour fully show the characteristics of the high speed steel, yet have special advantages over the known high speed steels. These new alloys differ from the high speed alloys in as much as they are practically free from carbon that is to say they contain carbon only in traces. These alloys consist of iron, 5 to 35% tungsten or of molybdenum or of tungsten and molybdenum and 5 to 50% of cobalt. These alloys are subjected to a different heat treatment than the carbon containing alloys hitherto used which were hardened merely by quenching. In contradistinction thereto the alloys according to the invention are hardened by precipitation hardening. For this purpose the alloys are first quenched from high temperatures. Yet by this quenching operation they are not hardened, but are in this state capable of being worked. It is only by reannealing them at temperatures of about 400–800° C. that they subsequently take up the high degree of hardness necessary for technical purposes. Thus, as far as the heat treatment is concerned, the new alloys differ fundamentally from the heretofore customary high speed steels and offer decided advantages over the high speed steel as well as the hard metal alloys of high capacity. First of all they are capable of being forged whereas the hard metals, such as those of the stellite type, may be used only in the form of castings and machined only by grinding. Furthermore, they are capable of being worked after quenching. This means that the final shaping may be effected subsequent to quenching whereas in the case of the high speed steel, it has to be carried out prior to the quenching operation. In this way one succeeds in preventing the finished tool from being subjected to the extraordinary high temperatures of 1200–1300° C. which are liable to cause an undesired distortion of the tool. On the other hand, by the subsequent reheating which causes only the high degree of hardness, changes in volume are produced of a size sufficiently small to be practically negligible. Hence it is made possible to manufacture the tools in a very clean state, since, after having been machined, they may be pickled and subsequently reannealed in a neutral or even in a decarburizing atmosphere. From the facts just mentioned it will be seen that decided technical improvements on the present practice of manufacturing tools may thus be accomplished.

One method of producing these new cutting alloys is shown by the following example: The alloy, in addition to the usual impurities (sulphur and phosphorus), contains 15% of tungsten, 30% of cobalt, 0.08% of carbon, 0.1% of silicon, 0.6% of manganese, balance iron. It has been quenched in oil at 1250° C. and reannealed at 650° C. for one hour. The hardness thus obtained was 710 units Brinell. It speaks well for the high quality of the alloy that a steel heat treated to proper toughness having a tensile strength of 110–150 kg./mm.$^2$ may be easily chipped.

The tungsten content of the alloy may be replaced partly or wholly by molybdenum. The cobalt content may be replaced partly or wholly by chromium, manganese, vanadium and other metals. It is to be understood that such further metals acting in the same manner as cobalt with respect to the phenomena dealt with by the present invention are comprised by the term "cobalt" used in the claim. Small amounts of rare metals such as titanium, zirconium, uranium

and others may also be added without departing from the spirit of the invention.

The composition and the heat treatment, as far as the height of the quenching—and reheating temperatures is concerned, depends upon the requirements that have to be met by the tool to be manufactured. The alloys may be used for the manufacture of tools of widely different types. Their use is not limited to chipping tools but may be extended to those which are subjected to wear, among which the following may be mentioned by way of example: cutting knives, files, drawing rings, drawing nozzles etc.

Having thus described my invention what I claim as new and desire to secure by Letters Patent is:

1. A substantially carbon free tool steel alloy containing 5 to 35% of tungsten and in addition 5 to 50% of cobalt, the balance consisting substantially of iron, said alloy having been hardened by precipitation hardening by heating the alloy between 900° C. and the melting point, rapidly cooling and heating between 400° and 800° C.

2. A substantially carbon free tool steel alloy containing 5 to 35% of molybdenum and in addition 5 to 50% of cobalt, the balance consisting substantially of iron, said alloy having been hardened by precipitation hardening by heating the alloy between 900° C. and the melting point, rapidly cooling and heating between 400° and 800° C.

3. A substantially carbon free tool steel allow containing 5 to 35% of tungsten and molybdenum and in addition 5 to 50% of cobalt, the balance consisting substantially of iron, said alloy having been hardened by precipitation hardening by heating the alloy between 900° C. and the melting point, rapidly cooling and heating between 400° and 800° C.

4. A tool steel alloy containing about 0.08% carbon, 5 to 35% of metal selected from a group consisting of tungsten and molybdenum, and in addition 5 to 50% cobalt and the balance substantially iron, said alloy having a Brinell hardness of about 710 obtained by precipitation hardening.

In testimony whereof I affix my signature.

WERNER KÖSTER.