Oct. 27, 1970 J. E. CONNOLLY 3,535,910

IMPACT TOOL

Filed March 11, 1966

FIG. 1

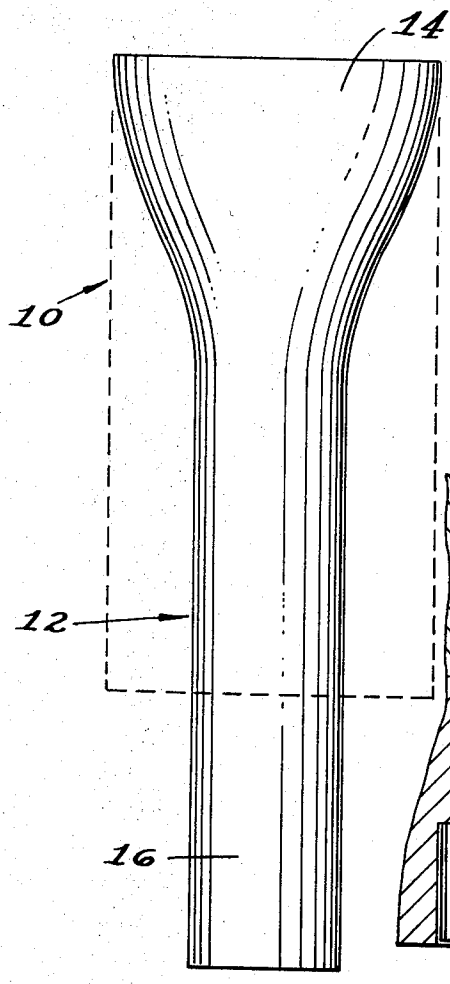
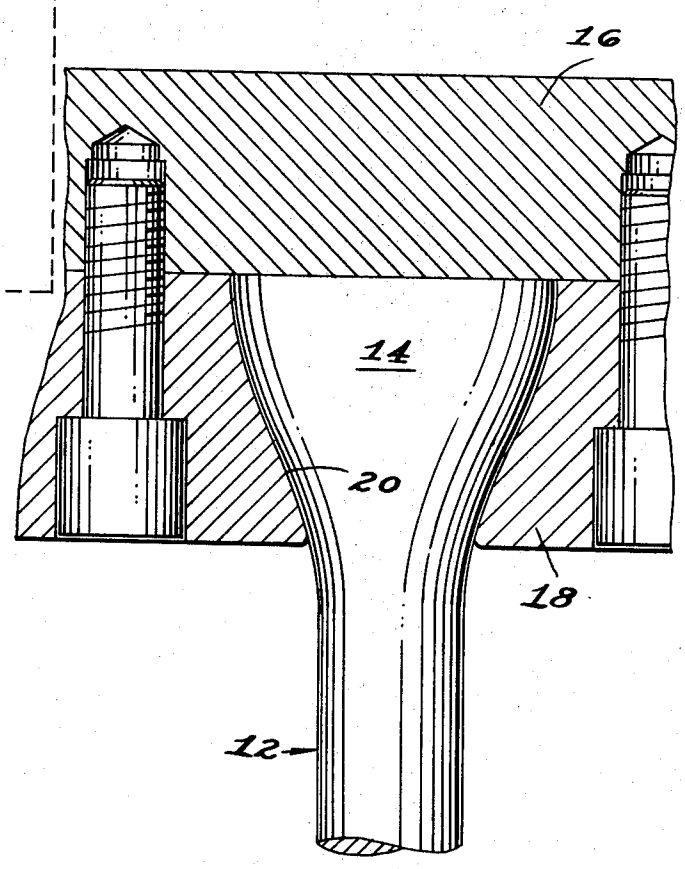


FIG. 2



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IMPACT TOOL

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ABSTRACT OF THE DISCLOSURE

An impact tool having a working shaft portion with an enlarged mounting head, the tool being an integral piece of metal which has been shaped to provide the mounting head to serve as a solid mount for the impact tool while creating in the shaft portion a metallic structure of tempered martensite which has exceptionally high strength and ductility to serve as an impact tool such as a chisel, metal punch, air hammer tool and so forth.

This invention relates to an impact tool and to the method of forming the same. It is common in formation of impact tools to have a head larger than the shaft of the tool to reduce the impact load on the head to prevent deformation and still transmit an adequate axial impact to the tool shaft. There are many types of tools to which the present invention is related, namely chisels, rock tools, metal punches, air hammer tools for concrete and rock, pin punches, punch-press punches, header punches, hot forging punches and the like.

It is an object of the present invention to provide an inexpensive means for forming a shock tool having ideal metallurgical characteristics in the shaft or tool and with an inherent basic form with an enlarged head resulting from the general formation of the part in the heat treating process.

Reference is made to the U.S. patent to Schmatz et al., No. 2,934,463, issued Apr. 26, 1960, directed to a method of producing a high strength steel and the disclosure of that patent is incorporated herein for a detailed disclosure on the process of creating a tempered martensitic structure.

This method involves a high degree of working on the metal itself to effect a material deformation in the metal as a part of the process of changing the metallurgical characteristics thereof. Accordingly, the disclosure of this patent is incorporated herein for the purpose of explaining the various metals that might be used and also the process of forming it. The compositions which are considered ideal for the shafts of the impact tools are generally referred to as ultrafine, grained martensite, hereinafter referred to, for purposes of convenience, as "tempered martensite."

High speed steels have proven in practice to be very shock sensitive, that is, subject to thermal and mechanical fatigue resulting from a slight crack or crevice on the surface resulting from tool marks and the like. In the present invention, it is intended that the tool be formed over highly polished dies without decarburization such that a fine surface is supplied to minimize the presence of these surface defects. In addition, high speed (.83 carbon tool steel) treated in the manner described in the Schmatz patent, above identified, not only shows extremely high strength common to high speed steels, but this is accompanied by a ductility which has never been previously obtained in high speed steel. Tests have indicated that the life of parts thus formed is two to eight times that of parts which have been conventionally heat treated.

The method of the Schmatz patent disclosure involves a high degree of working of the metal from the point of view of volume change. It is an object of the present invention to use the characteristic of the forming process to produce a shape inherently desirable in the tools to be made.

Other objects and features of the invention relating to details of construction and operation will be apparent in the following description and claims.

Drawings accompany the disclosure and the various views thereof may be briefly described as:

FIG. 1, a general outline of an impact tool.

FIG. 2, a view of an impact tool as conventionally mounted.

Referring to the drawings:

In FIG. 1, there is shown in dotted lines a slug of material **10** which is to be used to form the punch **12** having a head **14** and a work shaft **16**. The slug **10** is preferably formed of a steel described in the Schmatz patent and in the process of heat treating which requires considerable deformation of the steel, the lower portion of the slug **10** is reduced in diameter and elongated to provide the shaft **16** which has the high strength characteristics described in the Schmatz patent. Highly polished die surfaces are used to provide a smooth part surface formed to within a few thousandths of an inch of final size. The upper portion of the final tool designated **14** continues to have a reasonably large area compared to the small end to absorb and distribute the loads which will be transmitted by a hammer or a bed plate. The forming can be accomplished without noticeable decarburization, thus contributing to a proper surface condition.

The tool is formed with a progressively decreasing diameter in a relatively smooth uniform curve so that there is a good distribution of the shock load to the punch with a uniform, low-concentrated, stress transition area to face the input of the loading. The deformation of the metal in the heat treat process can vary from 25 percent on up, but it is preferred that it be in the area of 75 percent to obtain best results.

In carrying out this invention, a suitable steel composition is first austenitized by heating to a suitable temperature and then quickly brought into the selected temperature region by quenching in a liquid maintained at the proper temperature which should fall within the selected temperature region. This temperature region lies between 600° F. and 1100° F. with a preferred range from 800° F. to 1050° F. However, the preferred range may vary according to composition and fabrication techniques. Baths of molten lead or molten salt will serve well for this purpose. When the steel composition has been quenched to the proper temperature, it is promptly worked to effect a substantial reduction of area before it has cooled below the selected temperature region into a region in which rapid transformation to bainite or other austenite decomposition products is possible. If the work is very severe, precautions should be taken that the metal is not heated by the energy of the working so as to approach or trespass in the temperature zone in which a transformation into pearlite is possible.

When the desired amount of deformation or work has been accomplished, the steel composition is quenched into the martensite transformation zone before any transformation of substance into austenite decomposition products takes place. This quench is into the martensite transformation zone and is sufficiently drastic to insure a predominantly martensitic microstructure. In most circumstances an ordinary water quench is adequate for this purpose.

The martensitic structure obtained by this quenching procedure must be tempered to obtain the optimum final results. Tempering may be accomplished at any temperature desired in the range of 150° F. to 750° F. depending upon the final properties desired. A progressive increase takes place in the ratio of yield strength to tensile

strength as the tempering temperature increases. This ratio is about 0.71 at 150° and increases to 0.93 at 600° F. The preferred tempering range is 350° F. to 700° F.

In the practice of this invention, it is preferred to rely upon chromium or nickel and chromium to stabilize the austenite against premature decomposition. However, it is to be understood that other elements known to have the same effect may also be so employed. Examples of such elements are boron, manganese and nitrogen.

To insure an adequate bay width between the pearlite transformation zone and the bainite transformation zone, additions of molybdenum may be made. A similar effect may also be had by additions of manganese, vanadium and tungsten.

Thus it will be seen that the high strength areas of the punch are produced in a small diameter in the shaft **12** as a result of the heat treating operation leaving a part which is inherently of the proper diameter and shape to serve as an impact tool with an enlarged head **14** and a work shaft **16**. This produces a part immediately adaptable to mounting in a conventional structure such as shown in FIG. 2 wherein an impact plate **16** has the impact tool **12** mounted by its head **14** retained by a plate **18** having a suitable opening **20** for surrounding the head **14** and holding it tightly to the base plate **16**. In most instances, the tool can be formed in the heat treating process and the deformation required thereby to within a few thousandths of an inch of the finished size. If necessary, some finished grinding can be used to size the part but no machining is necessary and thus surface cuts and abrasions can be avoided.

The resulting tool can receive loads as high as 400,000 pounds per square inch and has a ductility as high as 10 percent with no bittle characteristics.

Thus, by utilizing the method of creating the best known metal characteristic for the punch itself, the shape desired is also obtained as well as proper surface condition for an ideal punch construction.

The small diameter of the tool formed in the dastic working of the metal at the temperature range of 750° to 1050° F. gives the so-called "ausform" strength and high ductility providing resistance to fracture and fatigue in the area where the high loads are present. The large diameter will remain with substantially normal characteristics where there is lower p.s.i. load.

In one example with a 60 percent reduction using H–13 tool steel, the hardness has varied from 59.5 to 61 (Rockwell Scale) in the small shank area and ranges down to 54 in the head area. The expected life of the tool can be extended three to five times that of normal tool steel heat treated in a conventional way.

What is claimed as new is as follows:

1. The method of making a steel punch of the type having a working shaft portion of elongate form of a predetermined cross-section and an enlarged mounting and driving head of substantially larger cross-section than the shaft which comprises:

(a) selecting a cylindrical slug of tool steel having a diameter substantially equal to the intended final diameter of the head of the punch,

(b) heating the slug to a temperature to obtain an austenitic grain structure,

(c) quenching the slug from a temperature range at which austenite is stable into a selected temperature region below the temperature at which austenite transforms into pearlite and drastically working one end of the slug within said temperature range to decrease its cross-section to the desired cross-section of the working shaft portion while maintaining the austenitic grain structure and while maintaining the basic cross-sectional dimension of the mounting head,

(d) quenching the formed punch from said temperature range to obtain a predominantly fine-grained martensitic structure in the worked end, and

(e) tempering the punch to obtain a high tensile and yield strength characteristic in the ensmalled end.

2. The method of making a steel punch of the type having a working shaft portion of elongate form of a predetermined cross-section and an enlarged mounting and driving head of substantially larger cross-section than the shaft which comprises:

(a) selecting a cylindrical slug of tool steel having a diameter substantially equal to the intended final diameter of the head of the punch,

(b) heating the slug to a temperature to obtain an austenitic grain structure,

(c) quenching the slug from a temperature range at which austenite is stable into a selected temperature region below the temperature at which austenite transforms into pearlite and drastically working one end of the slug within said temperature range to decrease its cross-section to the desired cross-section of the working shaft portion and to form a transitional portion between said shaft and said head of gradually increasing cross-section while maintaining the austenitic grain structure and while maintaining the basic cross-sectional dimension of the mounting head,

(d) quenching the formed punch from said temperature range to obtain a predominantly fine-grained martensitic structure in the worked end, and

(e) tempering the punch to obtain a high tensile and yield strength characteristic in the ensmalled end.

3. A steel impact tool comprising a working shaft portion of elongate form of a predetermined diameter, an enlarged mounting head portion of approximately twice the diameter of the shaft, and a blending portion between said shaft and head portions curving gradually from the shaft portion to the head portion, the shaft of said tool being formed by the process of creating tempered martensite which comprises heating a cylindrical slug of steel to a temperature sufficient to render the structure of the steel austenitic, the chemical composition of said steel slug being such that it exhibits a metastable austenite structure under conditions of substantial working when quenched from a temperature at which austenite is stable into a selected temperature region below the temperature at which austenite transforms into pearlite and above the temperature at which austenite transforms into bainite within the time necessary for the working process, quenching the entire slug as an austenitic mass sufficiently drastically to avoid any transformation into pearlite and to bring the slug to the selected temperature region without permitting any substantial transformation into bainite, performing a substantial amount of work upon one end of the steel slug while maintaining the temperature of the slug within the selected region, said work being sufficient to effect a substantial reduction in cross-sectional diameter at said one end to form a working shaft, quenching the steel slug from the selected temperature region to a temperature at which the isothermal transformation products will be predominantly martensitic and tempering the martensitic structure so obtained to increase the yield point and to narrow the range between the yield point and the tensile strength whereby a fine grained martensitic product is obtained in the reduced end of the slug in which the martensitic grain size is substantially smaller than the martensitic grain size of the remainder of the slug which is transformed directly to martensite without working of the metastable austenite, the resulting piece being thereby dimensioned for use as an impact tool with a mounting and drive portion at the large end and a working portion at the small end.

4. An impact tool of the type having a work shaft portion of reduced diameter and a head portion of large diameter connected by a curved blending area, said tool being formed without machining from a piece of high speed steel, the shaft being subjected to a forming process to create the reduced diameter and simultaneously produce a highly ductile metal of the nature of tempered martensite by a process which comprises heating a selected steel slug to a temperature sufficient to render the

structure of the steel austenitic, the chemical composition of said steel slug being such that it exhibits a metastable austenite structure under conditions of substantial working when quenched from a temperature at which austenite is stable into a selected temperature region below the temperature at which austenite transforms into pearlite and above the temperature at which austenite transforms into bainite within the time necsssary for the working process, quenching the entire slug as an austenitic mass sufficiently drastically to avoid any transformation into pearlite and to bring the mass to the selected temperature region without permitting any substantial transformation into bainite, performing a substantial amount of work upon one end of the steel slug while maintaining the temperature of the slug within the selected region, said work being sufficient to effect a deformation of at least twenty-five percent at one end to form a working shaft, quenching the steel slug from the selected temperature region to a temperature at which the isothermal transformation products will be predominantly martensitic and tempering the martensitic structure so obtained in the ensmalled end to increase the yield point and to narrow the range between the yield point and the tensile strength whereby a fine grained martensitic product is obtained in the reduced end of the slug in which the martensitic grain size is substantially smaller than the martensitic grain size of the remainder of the slug which is transformed directly to martensite without working of the metastable austenite, the resulting piece being thereby dimensioned for use as an impact tool with a mounting and drive portion at the large end and a working portion at the small end.

5. An impact tool of the type having a work shaft portion of reduced diameter and a head portion of large diameter connected by a curved blending area, said tool being formed without machining from a piece of high speed steel, the shaft being subjected to a forming process to create the reduced diameter and simultaneously produce a highly ductile metal of the nature of tempered martensite by a process which comprises heating a selected steel slug to a temperature sufficient to render the structure of the steel austenitic, the chemical composition of the steel slug including sufficient chromium that it exhibits a metastable austenitic structure under conditions of substantial working when quenched from a temperature at which austenite is stable into a selected temperature region below the temperature at which austenite transforms into pearlite and above the temperature at which austenite transforms into pearlite and above the temperature at which austenite transforms into bainite within the time necessary for the working process, quenching the entire slug as an austenitic mass sufficiently drastically to avoid any transformation into pearlite and to being the mass to the selected temperature region without permitting any substantial transformation into bainite, performing a substantial amount of work upon the one end of the steel slug while maintaining the temperature of the slug within the selected region, said work being sufficient to effect a deformation of at least twenty-five percent at one end to form a working shaft, quenching the steel slug from the selected temperature region to a temperature at which the isothermal transformation products will be predominantly martensitic and tempering the martensitic structure so obtained in the ensmalled end to increase the yield point and to narrow the range between the yield point and the tensile strength whereby a fine grained martensitic product is obtained in the reduced end of the slug in which the martensitic grain size is substantially smaller than the martensitic grain size of the remainder of the slug which is transformed directly to martensite without working of the metastable austenite, the resulting piece being thereby dimensioned for use as an impact tool with a mounting and drive portion at the large end and a working portion at the small end.

6. An impact tool of the type having a work shaft portion of reduced diameter and a head portion of large diameter connected by a curved blending area, said tool being formed without machining from a piece of high speed steel, the shaft being subjected to a forming process to create the reduced diameter and simultaneously produce a highly ductile metal of the nature of tempered martensite by a process which comprises heating a selected steel slug to a temperature sufficient to render the structure of the steel austenitic, the chemical composition of said steel slug being such that it exhibits a metastable austenitic structure under conditions of substantial working when quenched from a temperature at which austenite is stable into a selected temperature region below the temperature at which austenite transforms into pearlite and above the temperature at which austenite transforms into bainite within the time necessary for the working process, said selected temperature region extending from six hundred degrees Fahrenheit to one thousand one hundred degrees Fahrenheit, quenching the entire slug as an austenitic mass sufficiently drastically to avoid any transformation into pearlite and to bring the mass to the selected temperature region without permitting any substantial transformation into bainite, performing sufficient work upon the one end of the steel slug while maintaining the temperature of the slug within the selected region to reduce the cross-section and deform the said one end at least ninety percent, quenching the steel slug from the selected temperature region to a temperature at which the isothermal transformation products will be predominantly martensitic and tempering the martensitic structure so obtained in said reduced end to increase the yield point and to narrow the range between the yield point and the tensile strength whereby a fine grained martensitic product is obtained in the reduced end of the slug in which the martensitic grain size is substantially smaller than the martensitic grain size of the remainder of the slug which is transformed directly to martensite without working of metastable austenite, the resulting piece being thereby dimensioned for use as an impact tool with a mounting and drive portion at the large end and a working portion at the small end.

7. An impact tool of the type having a work shaft portion of reduced diameter and a head portion of large diameter connected by a curved blending area, said tool being formed without machining from a piece a high speed steel, the shaft being subjected to a forming process to create the reduced diameter and simultaneously produce a highly ductile metal of the nature of tempered martensite by a process which comprises heating a selected steel slug to a temperature sufficient to render the structure of the steel austenitic, the chemical composition of the steel including sufficient chromium that it exhibits a metastable austenitic structure under conditions of substantial working when quenched from a temperature at which austenite is stable into a selected temperature region below the temperature at which austenite transforms into pearlite and above the temperature at which austenite transforms into bainite within the time necessary for the working process, said selected temperature region extending from six hundred degrees Fahrenheit to one thousand one hundred degrees Fahrenheit, quenching the entire slug as an austenitic mass sufficiently drastically to avoid any transformation into pearlite and to bring the mass to the selected temperature region without permitting any substantial transformation into bainite, performing a substantial amount of work upon one end of the steel slug while maintaining the temperature of the slug within the selected region, said work being sufficient to effect a deformation of at least twenty-five percent at one end to form a working shaft reduced in cross-section from that of the original slug, quenching the steel slug from the selected temperature region to a temperature at which the isothermal transformation products will be predominantly martensitic and tempering the martensitic structure so obtained in the reduced end to

increase the yield point and to narrow the range between the yield point and the tensile strength whereby a fine grained martensitic product is obtained in the reduced end of the slug in which the martensitic grain size is substantially smaller than the martensitic grain size of the same steel in the remainder of the slug which is transformed directly to martensite without working of the metastable austenite, the resulting piece being thereby dimensioned for use as an impact tool with a mounting and drive portion at the large end and a working portion at the small end.

8. An impact tool of the type having a work shaft portion of reduced cross-section and a head portion of large cross-section connected by a curved blending area, said tool being formed without machining from a piece of high speed steel, the shaft being subjected to a forming process to create the reduced diameter and simultaneously produce a highly ductile metal of the nature of tempered martensite by a process which comprises selecting a slug having a steel composition exhibiting a metastable austenitic structure under conditions of working when quenched from a temperature at which austenite is stable into a selected temperature region below the temperature at which austenite transforms into pearlite and above the temperature at which austenite transforms into bainite within the time necessary for the working process, heating the steel slug to render it stably austenitic, quenching the austenitized hardenable alloy steel composition sufficiently drastically to avoid any transformation into pearlite and to bring the composition to the selected temperature region, performing a substantial amount of work upon one end of the steel slug while maintaining it in said selected temperature region until the substantial amount of work has been completed to reduce the cross-section of said one end, said work being sufficient to effect a deformation of said end to at least twenty-five percent, quenching the entire slug from the selected temperature region to a temperature at which the transformation products will consist essentially of martensite, said quenching operation being sufficiently drastic to insure a structure consisting essentially of martensite, and tempering the martensitic structure so obtained in said reduced end to narrow the range between the yield point and the tensile strength and to enhance the ductility, whereby a product is obtained in which the martensitic grain size in said one end is not over one-half of the martensitic grain size of the head end of the slug which is transformed directly to martensite without working of the metastable

austenite, the resulting piece being thereby dimensioned for use as an impact tool with a mounting and drive portion at the large end and a working portion at the small end.

9. An impact tool of the type having a work shaft portion of reduced diameter and a head portion of large diameter connected by a curved blending area, said tool being formed without machining from a piece of high speed steel, the shaft being subjected to a forming process to create the reduced diameter and simultaneously produce a highly ductile metal of the nature of tempered martensite by a process which comprises selecting a slug having a steel composition exhibiting a metastable austenitic structure under conditions of working when quenched from a temperature at which austenite is stable into a selected temperature region below the temperature at which austenite transforms into pearlite and above the temperature at which austenite transforms into bainite within the time necessary for the working process, heating the slug to render it stably austenitic, quenching the austenitized hardenable alloy steel composition sufficiently drastically to avoid any transformation into pearlite and to bring the composition to the selected temperature region, performing a substantial amount of work upon one end of the slug to reduce the cross-section while maintaining it in said selected temperature region until the substantial amount of work has been completed, said work being sufficient to effect a deformation of said end of at least ninety percent, quenching the entire slug from the selected temperature region to a temperature at which the transformation products will consist essentially of martensite, said quenching operation being sufficiently drastic to insure a structure consisting essentially of martensite, and tempering the martensitic structure so obtained, the resulting piece being thereby dimensioned for use as an impact tool with a mounting and drive portion at the large end and a working portion at the small end.

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RICHARD J. HERBST, Primary Examiner

U.S. Cl. X.R.

148—12.4