Sept. 26, 1961 J. F. SHERRILL 3,001,279

METHOD OF WORKING HARD BRITTLE METALS

Filed May 28, 1956

FIG. 1.

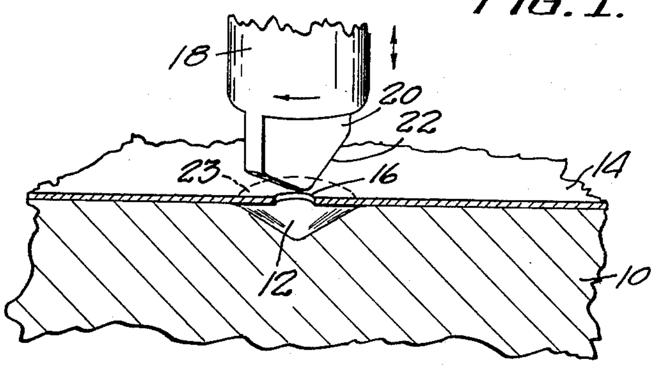


FIG. 2.

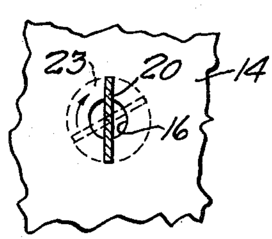


FIG. 3.

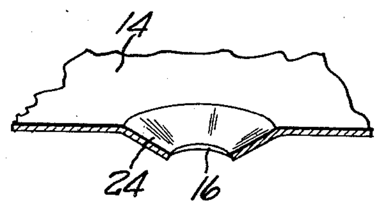


FIG. 4.

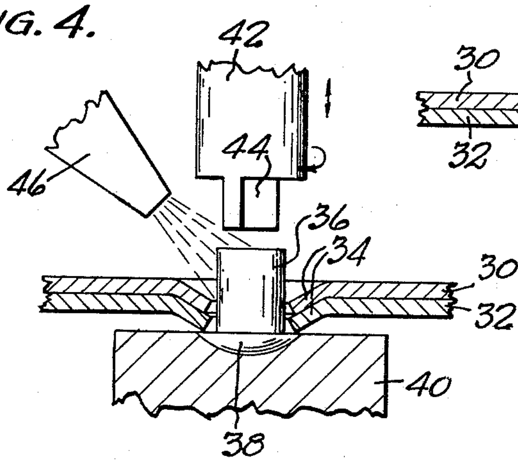
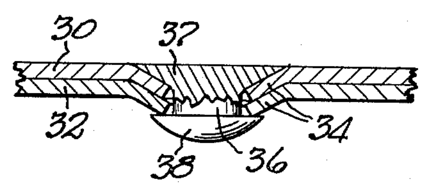


FIG. 5.



INVENTOR.

JOHN F. SHERRILL.

BY Eugene C. Knoblock

ATTORNEY.

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METHOD OF WORKING HARD BRITTLE METALS

John F. Sherrill, Plymouth, Ind., assignor to Eva R. Lemert, Plymouth, Ind.

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This invention relates to a method of working hard brittle metals.

Certain metals which possess valuable physical properties, such as great strength, ability to withstand high temperatures, and the the like, possess other properties, such as brittleness and frangibility, which make the working thereof difficult, expensive and time-consuming. Examples of such metals are titanium alloys, magnesium alloys, certain aluminum alloys, and stainless steel, each of which is characterized by extreme hardness and brittleness and lack of workability when cold. Thus such metals tend to break when subjected to hard or heavy blows, as in punching, piercing, offsetting or dimpling or shaping thereof.

As a result of these properties, it has been common heretofore to drill holes to be formed therein, even though the metal is of thin section. In cases where the metal is to be formed by offsetting, dimpling or shaping of sheets, or by the upsetting or heading of bars, shafts or rivets, it has been customary to heat the metal before performing the forming operation. One example of prior processes entails the operation of forming dimples or recesses in titanium alloy sheets used in aircraft where the recesses are required to receive a rivet head whose outer surface will be substantially flush with the sheet around the dimple. The practice in preparing such sheets has commonly been to drill each of the rivet holes individually and then to heat the sheet and work it to form the dimples or recesses around the openings. Frequent handling of the sheet to reheat the same as dimples are formed in a plurality of close spaced areas at the margin of a sheet consumes a large amount of time. After this formation it is necessary, when the dimpled sheets are to be secured together, to heat the rivets employed to secure the sheets and to work the rivets to head them while hot.

Such hot working of metals is very hard on the dies whose life is short and which require frequent replacement at great expense. Furthermore, the time required for hot working of the metal is much greater than would be required for cold working, so that labor costs under past hot working methods of treating hard alloys have been very high.

I have found that it is possible to work such metals while cold without danger of fracture, weakening or otherwise endangering the desired properties of the metal, and it is the primary object of this invention to overcome the disadvantages of the hot working methods described above and to accomplish effectively, quickly and inexpensively the forming of hard and brittle metals by a cold working process.

Other objects will be apparent from the following specification.

In the drawing:

FIG. 1 is a view illustrating a step in the process of forming a dimple in hard metal around an opening therein;

FIG. 2 is a schematic view illustrating a part of the process;

FIG. 3 is a fragmentary sectional view of a dimpled member formed by my process;

FIG. 4 is a side view with parts shown in section, illustrating the process of forming a head on a rivet;

FIG. 5 is a cross-sectional view illustrating the formed rivet in its clinching position; and

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My method, broadly stated, entails the working of metal by impact at high speed at a limited area of the workpiece while continually and progressively changing the location of the tool, so that different areas of the work piece are struck by successive blows, and wherein the blows are limited to a value less than the physical fatigue limit of the metal.

Referring to the drawing, and particularly to FIGS. 1, 2 and 3 which illustrate the application of my process to the work of dimpling sheet metal, the numeral **10** designates a support, work table or anvil, having a cavity or recess **12** formed therein of approximately the shape and size of the area to be dimpled. The sheet **14** of metal to be worked rests upon the surface of the member **10** and spans the cavity **12**. In cases where a dimple is to be formed around an aperture **16**, the aperture **16** will be centered with the cavity and will have been preformed, as by drilling. A hammer member **18** is caused to reciprocate in a direction perpendicular to the work-supporting surface of the member **10** and in coaxial relation with the aperture **16** in the work piece and with the cavity **12** in the work support **10**. The rate of reciprocation will be rapid and preferably substantially uniform. Thus the reciprocation may be at a slow rate to apply as few as four or five hundred blows per minute or at higher rates, such as a rate to apply sixteen thousand or more blows per minute. The blows will be of substantially uniform value so as to have a predetermined total pressure or impact value per unit of time. In general, the force of the individual blows will usually be substantially inversely proportional to the number of blows. Thus each blow delivered at the rate of 500 blows per minute could be much heavier than the individual blows delivered at the rate of 16,000 blows per minute. In all cases care must be taken to limit the force of each blow to a value less than that which would injure the work piece, i.e., must be restrained within the physical fatigue limits of the material.

Simultaneously with the reciprocation of the hammer **18** to apply blows rapidly, said hammer is rotated about its axis or otherwise shifted to change the location of successive blows upon the work area. The hammer **18** preferably terminates in a thin longitudinal blade portion **20** whose tip is tapered at **22** in substantial conformity with the depth, size and angle of the conical dimple to be formed. As a result of such formation of the hammer head or blade **20**, it will be evident that only a small portion of the area of the sheet which is to be deformed, such as the bevel **24** shown in FIG. 3, is contacted by the blade **20** upon each stroke or hammer blow thereof. The hammer blows will be directed at the work sheet at the area **23** to be reshaped to form the dimple **24** and as outlined by the dotted circular line in FIG. 2.

As a result of the rapidity of the hammering operation, heat is generated within the sheet but the amount of heat usually does not greatly exceed 100 degrees F. and is not sufficient to cause heat damage to the work piece or expansion thereof. In cases where magnesium alloys are involved, the heat generated will not be sufficient to cause combustion to occur.

As an example of the process, a vanadium type titanium alloy commonly used for aircraft purposes has a hardness producing a Rockwell A reading in the order of 70. I have found that sheets of this material can be effectively dimpled while cold by using a tool having a blade or peen thickness of about 1/16 of an inch which is oscillated at the rate of between 6,500 and 16,000 blows per minute, and preferably approximate 7000 blows per minute, with each blow delivering a force of about one-quarter pound in the lower part of the range and reducing progressively as the frequency of blows is increased, and with the hammer or peen blade being rotated at a speed of approximately 1200 revolutions per minute or more. The ratio between the force of the blows and the frequency of the blows will be such that the total force exerted per unit of time will be substantially the same throughout the full range of speed adjustment.

Another example of successful cold working of a brittle alloy used in the aircraft industry and successfully cold worked by my method is known as "75 S.T. 6 aluminum alloy." This metal has a Rockwell A rating of about 40. In practicing my method on this material I employ a hammer having a blade one-quarter inch thick which is oscillated at the rate from 1500 to 3500 blows per minute and preferably approximately 2000 blows per minute. Each blow exerts a force of about one pound at the lower end of the range, and less, as one-half pound, at the upper end of the range. The hammer is rotated at 1200 r.p.m. or faster.

In both examples, the width of the blade is substantially less than the total area of the surface to be worked, and the rate of speed of rotation is such that successive blows by the blade contact different areas of the work piece within the total area to be reformed. The time required for the performance of the dimpling operation in both cases is approximately one-half of the time which would have been required for dimpling the same work piece by the conventional hot working methods.

FIGS. 4 and 5 illustrate another application of the method, namely, the formation of a head upon a rivet formed of hard brittle or frangible material to seat in a dimple so as to have a finished surface substantially flush with the surface of a metal surrounding the dimple. Two metal sheets **30** and **32** have dimpled or recessed portions **34** encircling apertures therein and registering and interfitting so as to receive therethrough the shank **36** of a rivet. The rivet will preferably have the preformed head **38** bearing against one edge or face of one of the sheets. A bucking tool **40** may be applied to the rivet head to hold the rivet in the opening while blows are applied to the end of the rivet **36** which is to be deformed. Blows are imparted to the end of the rivet shank **36** by a hammer **42** which reciprocates rapidly in a direction parallel to the axis of the rivet shank and whose work-engaging part is a narrow blade **44** projecting longitudinally at its end. The hammer is rotated as it oscillates so that successive blows are applied to different areas of the end of the rivet shank **36**. The rate of speed at which the blows are imparted, the force exerted by each blow, and the rate of rotation of the hammer, together with the width of the blow-imparting blade **44**, will all be of the order described above with reference to the operation of forming a dimple. The principal difference in this instance will be the fact that the blow-imparting edge of the blade **40** will preferably be flat rather than pointed or tapered as in the prior construction. The hammering is continued until the tapered rivet head **37**, substantially flush with the surface of the sheet **30**, is formed, as illustrated in FIG. 5.

The cold working method involved, both with respect to the dimpling or offsetting operations and with respect to the head-forming operation, is advantageously performed while the work piece is covered with a lubricant. This is especially desirable for titanium alloys. In such cases an oil having a sulphur base has been found particularly well suited as the lubricant. The sulphur base of the oil is important because it tends to avoid sticking and galling of the work. The manner in which the lubricant is applied is optional but one method is to spray the same onto the surface area of the work which is being processed, as by means of a spray nozzle **46** discharging a spray of the lubricant onto the work, as illustrated in FIG. 4.

Any means found suitable for controlling the rate of impact, the force of impact and the rotation of the hammer with respect to the work piece may be employed.

One example of such apparatus is illustrated in my copending application for Variable Speed Fluid Pressure Actuation Impact Device, Serial No. 507,589, filed May 11, 1955. Any other apparatus suitable for the performance of the steps required to rapidly hammer limited portions of an area to be worked for the purpose of slightly but progressively deforming the total area by light hammer blows, may be employed.

While the preferred steps of the method have been described, it will be understood that the method is not limited precisely thereto, but that any procedure which falls within the scope of the appended claims is contemplated within the spirit of the invention.

I claim:

1. The method of working sheet metal characterized by hardness and brittleness while cold and selected from the group consisting of titanium alloys, magnesium alloys, aluminum alloys and stainless steel, consisting of the step of hammering the sheet metal, while it bears on a supporting surface surrounding an interruption, at an area of the sheet metal registering with said interruption with a hammer having an elongated narrow work-engaging surface whose area is small compared to the area being hammered, said hammering occurring while said metal is cold and substantially uniformly at a rate in the range between 400 blows per minute and 16,000 blows per minute and at a force less than the fatigue limit of the metal to deform said sheet metal at the hammered area thereof, said hammer being continuously rotated to successively engage different parts of the area registering with said support interruption as long as said hammering continues and in a manner to contact all of the surface of the area registering with said support.

2. The method of working sheet metal characterized by hardness and brittleness while cold and selected from the group consisting of titanium alloys, magnesium alloys, aluminum alloys and stainless steel, consisting of the step of hammering the sheet metal, while it bears on a supporting surface surrounding an interruption, at an area of the sheet metal registering with said interruption with a hammer having an elongated narrow work-engaging surface whose area is small compared to the area being hammered, said hammering occurring while said metal is cold and substantially at a rate in the range between 400 blows per minute and 16,000 blows per minute and at a force less than the fatigue limit of the metal, to deform said metal at the hammered area thereof, said hammer being continuously rotated to successively engage different parts of the area registering with said support interruption as long as said hammering continues and in a manner to contact the entire area registering with said interruption, the rapidity of said hammering in the aforesaid range being substantially proportional to the hardness of the sheet metal and the force of each hammer blow being inversely proportional to the hardness of the sheet metal.

3. The method of working sheet metal characterized by hardness and brittleness when cold and selected from the group consisting of titanium alloys, magnesium alloys, aluminum alloys and stainless steel, consisting of the step of hammering an unsupported area of the sheet metal while supported on a surface having a recess with a hammer having a work-engaging surface inclined relative to said sheet metal and whose area is small compared to the size of the area registering with said recess and which is to be worked, said hammering occurring while the metal is cold and substantially uniformly at a rate in the range between 400 blows per minute and 16,000 blows per minute, each blow being of a force less than the fatigue limit of the metal but sufficiently to progressively deform the metal being hammered without rupture, said hammer being continuously rotated to successively engage and deform different parts of the unsupported area to be worked as long as said hammering

continues and in a manner to hammer all of the area registering with said recess, said sheet being supported at the portion around the area being worked.

4. The method of forming a tapered dimple around a preformed hole in hard frangible sheet metal selected from the group consisting of titanium alloys, magnesium alloys, aluminum alloys and stainless steel, consisting of the step of simultaneously reciprocating and rotating an impact tool having a narrow U-shaped tip providing oppositely inclined narrow impact surfaces to hammer said sheet metal at an unsupported area thereof around said hole while said metal is cold and is supported on a surface having a recess with which the area to be worked registers to thereby deform the same progressively and fragmentarily by small increments, the rapidity of the blows and the force of each blow depending upon the hardness of the metal, so that the force of each blow and the width of the impact surface of the tool are inversely proportional to the rapidity of the blow.

5. The method of working hard frangible sheet metals having a Rockwell A reading in the order of 70 consisting of the step of simultaneously reciprocating and rotating a tool having a transversely elongated impact surface approximately 1/16 inch wide to hammer a limited unsupported area of the metal to be worked while bearing on a support around an interruption thereof, said hammering occurring at successively different limited portions of the area registering with said support interruption, said hammering occurring at a rate in the range between 6,500 and 16,000 blows per minute and with exertion of a force of approximately one-quarter pound per blow in the lower part of said speed range and with exertion of an inversely proportional force in the upper part of said speed range, said impact surface being angularly disposed relative to said sheet metal.

6. The method of working frangible sheet metals having a Rockwell A reading in the order of 40 consisting of the step of simultaneously reciprocating and rotating a tool having a transversely elongated V-shaped impact surface approximately 1/8 inch wide to hammer successively while mounted on a support having an interruption intermediate thereof, different limited portions of the unsupported area of said sheet metal registering with the interruption of said support, wherein said hammering occurs while said sheet metal is cold and at a rate in the range between 1,800 and 3,500 blows per minute each of a force in the range of approximately one pound at low speeds in said speed range to one-half pound at high speeds in said speed range.

7. The method of working apertured hard frangible sheet metal to deform the same while cold, consisting of the step of simultaneously applying lubricant to the area of the metal to be worked and hammering and rotating an impact tool having a narrow elongated work-engaging portion having a working surface at an acute angle to the axis of the tool to impart in rapid succession to different parts of an area of the sheet metal registering with a recess in a member supporting said sheet metal and surrounding an aperture in said sheet metal blows of a force each only adequate to slightly or partially deform the limited area of the metal which is engaged by said tool, wherein the rapidity and force of the blow and the dimension of the work-engaging portion of the tool vary in proportion to the hardness of the metal and substantially in the order and ratios of the following examples:

	Example 1	Example 2
Metal with Rockwell A reading of	40	70.
Hammer blows per minute, approx.	2,000	7,000.
Force of each blow, approximately	1 pound	1/4 pound.
Width of hammer, approximately	1/4 inch	1/8 inch.

References Cited in the file of this patent

UNITED STATES PATENTS

1,430,692 Seng ---- Oct. 3, 1922
1,585,327 Booker ---- May 18, 1926
1,910,954 Knuuti ---- May 23, 1933
2,156,167 Snyder et al. ---- Apr. 25, 1939
2,382,045 Flowers ---- Aug. 14, 1945
2,393,131 Vang ---- Jan. 15, 1946
2,413,518 Rechton et al. ---- Dec. 31, 1946
2,441,517 Sussman ---- May 11, 1948
2,578,585 Orozco ---- Dec. 11, 1951
2,697,953 Chapman ---- Dec. 28, 1954

OTHER REFERENCES

Schuster et al.: Abst. of application S.N. 37,498, pub. Nov. 20, 1951, O. G. vol. 652.