Aug. 4, 1953 L. F. KNIGHT ET AL 2,647,979

METHOD AND APPARATUS FOR FORMING LARGE UPSETS

Filed June 27, 1952 3 Sheets-Sheet 1

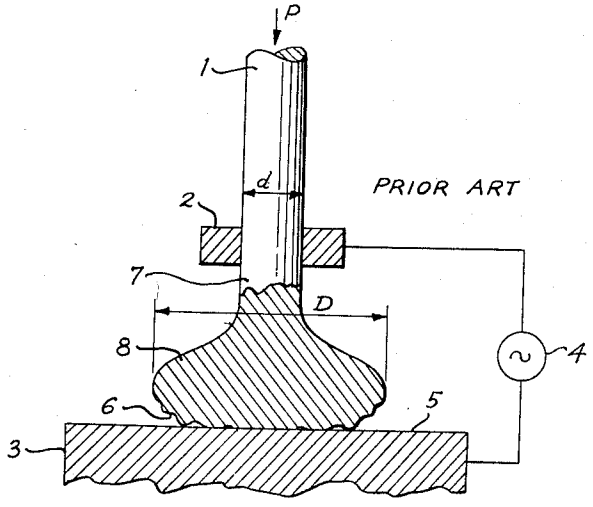


Fig. 1

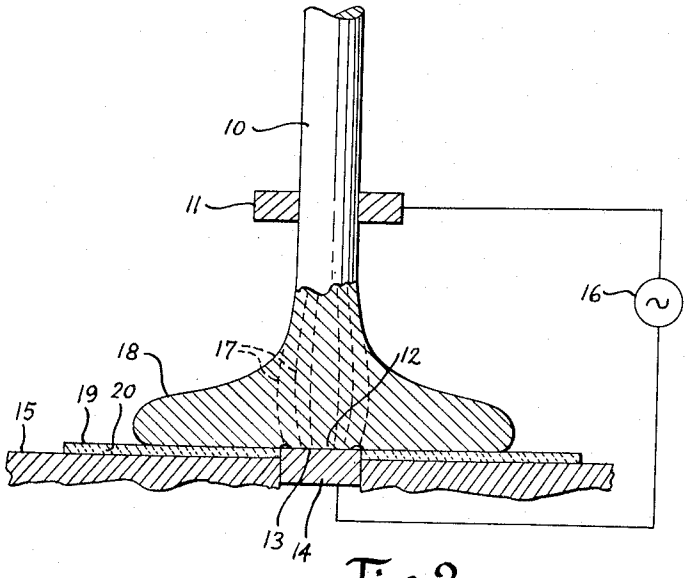


Fig. 2

Inventor
LORNE F. KNIGHT &
ARNOLD PITT
by: Fetherstonhaugh & Co.
Atty's.

METHOD AND APPARATUS FOR FORMING LARGE UPSETS

Filed June 27, 1952 3 Sheets-Sheet 2

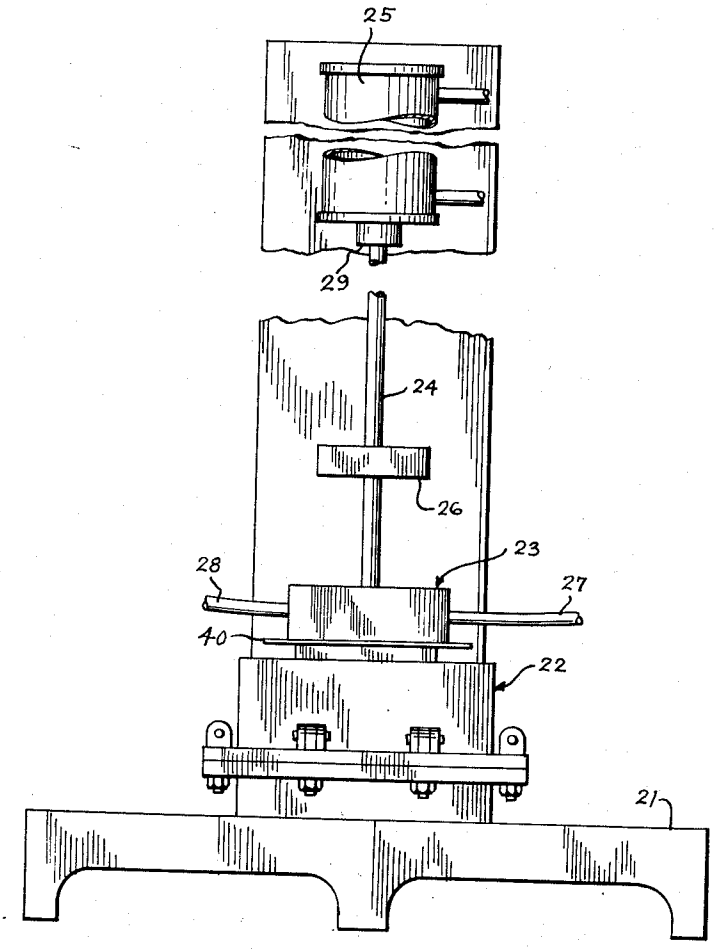


Fig. 3

Inventor
LORNE F. KNIGHT &
ARNOLD PITT,
by: Fetherstonhaugh & Co.
Attys

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3 Sheets-Sheet 3

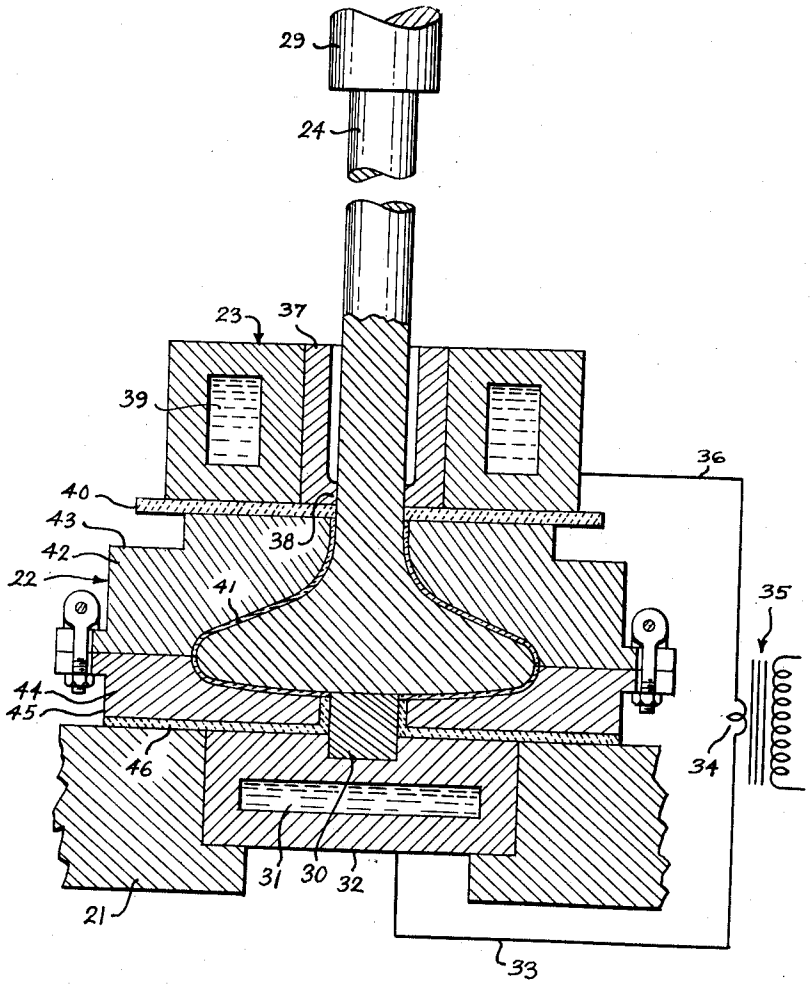


Fig. 4

Inventor
LORNE F. KNIGHT &
ARNOLD PITT
by: Fetherstonhaugh & Co.
Attys

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METHOD AND APPARATUS FOR FORMING LARGE UPSETS

Lorne F. Knight, Toronto, Ontario, and Arnold Pitt, Weston, Ontario, Canada, assignors to Massey-Harris Company, Limited, Toronto, Ontario, Canada

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8 Claims. (Cl. 219—3)

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This invention relates to a method and apparatus for forming large upsets with small pressures.

In order to fully appreciate the invention it is necessary to refer to the prior art wherein Figure 1 of the drawings represents diagrammatically methods heretofore practiced. In referring to this figure, it will be observed that a bar or rod 1 is subjected to a positive pressure P being forced through the collar electrode 2 to engage the forming head electrode 3, the electrodes 2 and 3 being in circuit with a source of high current, low voltage energy 4. As the material of the bar heats up between the electrodes 2 and 3 and under application of pressure, the end of the bar in engagement with the forming surface 5 of the forming head 3 spreads thereover. However, it is important to observe that two conditions arise as the upset is developed.

(*a*) The skin of the upset during formation as it touches the cold forming surface 5 shrinks therefrom and then, under the influence of more material flowing thereover, moves toward this cold surface and again shrinks therefrom, resulting in multiple undulations 6.

(*b*) As the diameter of the upset increases, the cross-sectional area of the upset in contact with the electrical conducting forming surface 5 reduces the overall resistance to the flow of electricity in this region and, therefore, the heating effect is materially and progressively reduced.

Accordingly, because of condition (*b*) the heating in the prior art method of upsetting after the formation of an upset sufficient to reduce the heating effect, takes place in the wrist portion 7 so that under application of large pressures P this material is forced over the colder, already formed, upset portions. The feed of the rod is steady, so that this condition does not lead to superposed layers, but the overall effect is one of moving the heat source further and further away from the forming surface 5 and thus progressively further away from the body of the material in the upset 8. Thus, it will be seen that in the prior method the generation of heat is at a point in the bar stock always substantially exterior of the upset being formed and, therefore, large upset ratios are impractical except with very large pressures. On the other hand, the amount of material required to be fed to form a large upset is limited by the slenderness ratio or buckling factor of the bar stock or rod being fed under pressure so that for all practical purposes in prior art methods requiring large feeding pressures, one is limited to the feeding of a length of bar stock

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less than ten times the diameter. Furthermore, the upset ratio (that is, the diameter of the upset D divided by the diameter of the bar *d*) is limited by the condition of forcing substantially exteriorly heated material over a cooler mass of material and by the condition that the undulations 6, as shown in Figure 1, become larger and larger until a point is reached where they limit the diameter to which the upset can be formed.

It is a particular object of the present invention to avoid the foregoing characteristics of prior methods of upsetting employing electrical resistance heating of bar stock, especially by containing the heating effect substantially within the upset as it is formed.

It is another object of the invention to provide method and apparatus for upsetting bar stock by the use of pressures of small order as compared with the magnitude of pressure required in conventional upsetting techniques.

It is a further object of the invention to control the form of the upset being formed by providing a forming surface in the forming head of lower heat conductivity than the material of the bar stock or rod being upset.

It is a still further object of the invention to provide method and apparatus for upsetting bar stock or the like wherein the forming head contains an electrode of a contact area less than the cross-sectional area of the upset to be formed, and preferably of a size conforming to the diameter of the bar stock to be upset.

With these and other objects in view, the apparatus of the invention generally comprises, a forming head; a forming surface on said forming head adapted to control the shape of an upset formed thereagainst and isolated from the material of the forming head by a material of relatively high electrical resistance and relatively low heat conductivity, wherein the said forming surface also includes an electrode surface adapted to be engaged by the rod or bar stock to be upset, and of a contact area less than the cross-sectional area of the upset to be formed. Means are provided for feeding the rod or bar stock through a collar-like electrode toward the electrode surface of the forming head, the electrode surface and the collar-like electrode being connected with a source of high current, low voltage electrical energy to cause the rod or bar stock to be heated therebetween.

The form of the apparatus may embody a forming surface in the forming head of such character that such surface define a hollow mould, in which case it will be appreciated that

the heating effect accomplished according to the invention is substantially confined to the interior of the mould.

The method of the invention generally comprises the steps of, upsetting bar stock or rod by passing the same through an electrode to engage an electrode surface, and passing electrical current therebetween to cause that portion of the bar between the electrodes to heat to a deforming temperature, confining the area of the electrode surface to a value less than the cross-sectional area of the upset to be formed and preferably to an area substantially conforming to the cross-sectional area of the bar stock to maintain the heating effect in regions within the upset being formed. The method also contemplates the provision of the steps of substantially maintaining the heat of the surface of the upset engaging the forming surface of the forming head.

Other objects of the invention will be appreciated by a study of the following specification taken in conjunction with the accompanying drawings.

Figures 2 to 4 illustrate the method and apparatus of the invention, wherein Figure 2 is a diagrammatic illustration of the general method of the invention.

Figure 3 is a front elevation of one form of apparatus according to the invention.

Figure 4 is a diagrammatic sectional illustration of the apparatus of Figure 2.

The method and apparatus of the invention is particularly adaptable for forming large upsets with a utilization of very small pressures. As illustrated in Figure 2, a rod 10 may be passed through a collar-like electrode 11 to cause the free end 12 to engage the electrode surface 13 of the forming head electrode 14. The latter is insulated from the main body of material of the forming head 15 and is connected electrically to the source of high current power 16, which latter is also connected to the collar electrode 11 to complete the electric circuit and cause a heating of the bar stock between the electrodes to a deforming temperature. This region of the bar or rod may be referred to as the deformable region.

After the deformable region has initially been heated to a deforming temperature, or concurrently with this heating, the rod is advanced whereby the material adjacent the electrode surface 13 spreads into an upset form. As indicated, the diameter or surface area of the electrode surface 13 preferably conforms to the diameter of the rod 10, so that, as the upset enlarges, the current path will substantially maintain its form and will conform in general to a pattern 17 of an effective area not materially greater than the original sectional area of the rod. This condition particularly obtains under the application of high current and low voltage as compared with the reverse situation.

As the material of the upset 18 being formed spreads over the forming head, the temperature of the "skin" of the upset is substantially maintained by allowing it to come into contact with a forming surface 19 of the forming head isolated from the main body of the material of the forming head 15 by a layer or layers 20 of a material of relatively high electrical resistance and relatively low heat conductivity as compared with the material of the rod itself. For example, a carbon layer would be suitable, or carborundum high resistance tungsten alloys supported by a ceramic base would also be suitable.

It will be observed that, in accordance with the concept illustrated by Figure 2, the material

of the rod 10 is advanced only at that rate necessary to supply material to the upset end at a rate conforming to the heating rate. The rod 10 is disposed vertically in the formation of very large upsets.

The forming surface of the forming head may be of any desired shape, and, in one form, may comprise a hollow mould adapted to be filled with material in the controlled manner illustrated, so that effectively the upset is formed into a mould or die. Apparatus suitable for this technique is illustrated in Figures 3 and 4.

Mould upsetting apparatus of one suitable form, as illustrated in Figures 3 and 4, comprises a machine bed 21 carrying a separable mould 22 of special character as hereinafter disclosed, over which is supported an electrode head 23 through which the shaft 24 to be upset is pressed by the hydraulic ram 25. Adjustable guides 26 are provided for supporting the shaft 24 against buckling and may be adjusted vertically as desired.

The electrode head 23 is water-cooled as hereinafter disclosed and is supplied with water by the inlet and outlet tubes 27 and 28. The machine bed 21 is also cooled. An electrical transformer of about 500 kva. rating and 12 volts output on the secondary is connected electrically to the head 23 and an electrical contact (not shown) in the anvil face (not shown) of the machine bed 21.

The apparatus is disclosed in more detail in Figure 4. In operation, the piston 29 of the ram 25 is engaged with the shaft 24 while the latter is supported against the contact block 30 set in the machine bed 21, the latter having suitable water communicating cooling ducts 31 therethrough. The contact block 30 is mounted in an anvil part or head 32 set in the bed 21 and is electrically connected to one lead 33 of the secondary 34 of the low-voltage high-current transformer 35. The other lead 36 of secondary 34 connects to the electrode head 23, the latter carrying a contacting sleeve 37 having a pressed fit contacting flange part 38 adapted to tightly engage the shaft 24. The contacting sleeve 37 is preferably formed of electrode bronze. The electrode head itself includes water cooling passages 39.

An insulation barrier 40 of mica or other suitable material is interposed between the electrode head 23 and the separable mould 22. The inner mould surfaces 41 of the mould are formed to a desired contour and comprise a ceramic material which may be replaced after each upsetting operation or may comprise a coating of titanium oxide. The body 42 of the mould part 43 and the body 44 of the mould part 45 may be formed of controlled density steel of relatively low density to accomplish a relatively low transfer as compared with full density metal. It will be apparent, however, that in cases where the mould stresses are low as may be accomplished in a manner hereinafter disclosed the mould body in the both parts may be formed entirely of ceramic material but supported by a metal jacket and wherein such material may effectively constitute an electrical insulator or at least of the characteristic of the high electrical resistance as compared with the electrical resistance of the shaft material. The mould 22 is insulated such as by a sheet of mica 46 from the anvil head 32. It will, however, be appreciated that the insulation 40 and 46 may not be necessary where the body of the mould is of an insulating material.

In operation, as electrical current passes between that portion of the shaft between the contacting flange **38** and the contact head **30** such portion of the shaft will be heated to a deforming temperature wherein the interior of the shaft in such portion will be heated to a point just below, if not at, the melting point of the metal of the shaft. The shaft is then advanced under action of the ram **25** to cause an upset into the mould cavity. The rate of advance, however, is preferably controlled to avoid splitting of the skin of the heated region as it bulges into the cavity and, in this way, the skin expands and is reformed as the upset expands. As the skin of the upset touches the inner mould surfaces **41**, the reflecting effect of these surfaces and their non-conducting nature tends to maintain the heat of the skin so that it does not contract and pull away from such surfaces before finally settling thereagainst. Accordingly, it is not necessary to resort to great pressures in the ram which would make the upsetting of very large diameters impossible with present press equipment according to conventional upsetting techniques.

It should be observed that the contact head **30**, being of a restricted area corresponding substantially to the area of the original diameter of the shaft, by virtue of the low voltage power employed effects a current path substantially conforming to the original diameter of the shaft in the upset portion as upsetting progresses. It is important to maintain the area of electrical contact to substantially the initial area of contact during upsetting in order to maintain the heating rate and it is for this reason that the insulation **46** and the insulated surfaces **41** are disclosed as forming a part of the preferred form of apparatus illustrated in Figure 4.

An obvious modification of the apparatus of Figure 4 would be the provision of a recessed contact head whereby a part of the shaft **24** would be retained in its original form, in which case the upset would be formed effectively in some region intermediate the original ends of the shaft. Accordingly, the invention is not limited to the upsetting of an end or even one end of a shaft, but the technique may be employed for multiple upsetting at various points in a shaft.

What we claim as our invention is:

1. The method of upsetting a metal bar or the the like, comprising the steps in combination of: passing an electrical current through the bar between two spaced apart points defining therebetween a deformable region and to cause the deformable region to heat to a deforming temperature; moving said bar toward a point contained within the deformable region and at which an upset is desired to be formed; and supporting at least a portion of the upset during formation with a material of effectively high electrical resistance and low thermal conductivity.

2. The method according to claim 1, and the step of supporting the entire upset being formed with the said material.

3. In the method of upsetting the end of a bar or the like by an electrical resistance heating technique against an anvil face, wherein the anvil serves as one electrode initially engaging the end of the bar, and a second electrode may be provided in the form of a ring-like structure spaced from the anvil and through which the bar may be moved during upsetting operations, the steps in combination of: maintaining the effective centre of heat generation within the upset being formed substantially within the core of the upset by restricting the area of electrical contact on the anvil face to a predetermined initial sectional area of the bar.

4. The method according to claim 3, and the step of supporting portions of the upset being formed with a material of relatively low heat conductivity.

5. Apparatus for forming large upsets on a metal bar or the like, comprising in combination: a pair of electrodes adapted to engage the bar at spaced apart points for passage of an electrical current through a deformable region of the bar therebetween to cause the deformable region to be heated to a deforming temperature, and means including a forming surface effectively electrically insulated from said electrodes of predetermined contour and positioned to receive portions of an upset formed thereagainst when the bar is moved in a direction toward said means.

6. Apparatus as claimed in claim 5, in which the means including a forming surface comprise, a cavity mould in which one of said electrodes is positioned.

7. Apparatus as claimed in claim 5, in which one of said electrodes is adapted to engage one end of the bar and is of a contact area substantially conforming to the area of the end of the bar.

8. Apparatus as claimed in claim 5, in which the means including a forming surface comprise, a separable cavity mould in which one of said electrodes is positioned; and means for advancing said bar in a direction toward said separable cavity mould.

LORNE F. KNIGHT.
ARNOLD PITT.

No references cited.