United States Patent

Clendenin et al.

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[54] **COLD EXTRUDED ARTICLE AND METHOD OF MAKING THE SAME**

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[52] **U.S. Cl.** **72/42,** 72/267, 72/358

[51] **Int. Cl.** **B21c 3/18,** B21d 22/00

[58] **Field of Search**......72/42, 46, 47, 267, 352, 353, 72/354, 358, 377, 700

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[57] **ABSTRACT**

A unitary cold extruded component of disc brakes for motor vehicles having directional properties imparted by different directional elongations of various portions thereof, said component having a generally U shaped cross-section with diverging sides of specific thickness and shape, a downwardly extending lower lip, all with accurately aligned and dimensioned planar surface portions is formed from an accurately dimensioned round rod portions of low carbon steel having metal grains therein elongated only in axial directions, by suitably coating the rod with drawing lubricant and subjecting the rod to deforming pressure applied transversely to its axis between male and female die members which make initial metal deforming contact along lines in the cylindrical surface of the rod the deformation being at a rate corresponding to the speed of travel of the ram of a mechanical punch or coining press moving at 30 to 80 strokes per minute. The directional cold elongations permit the component to be substituted for components before made only from expensive alloy steels by a machining process.

3 Claims, 5 Drawing Figures

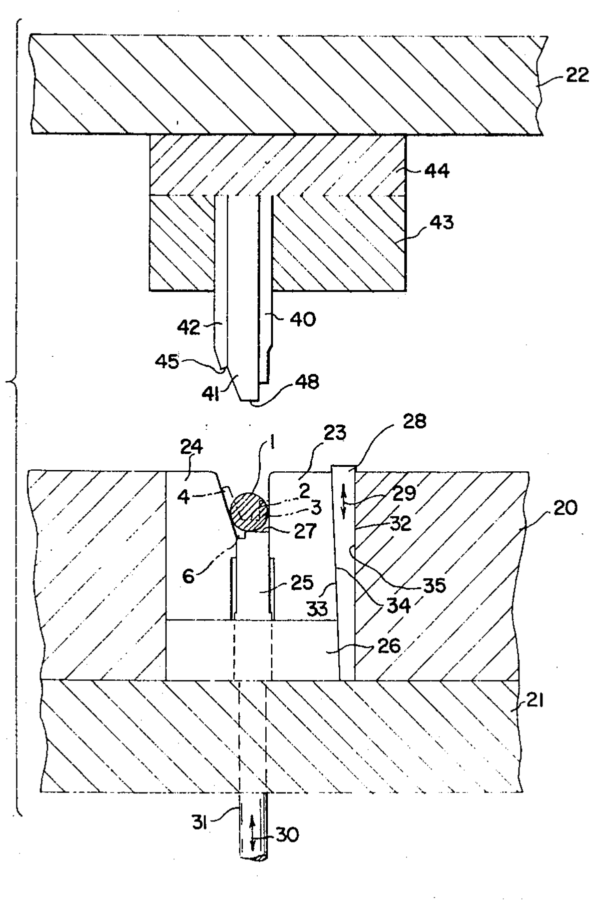

FIG. 1

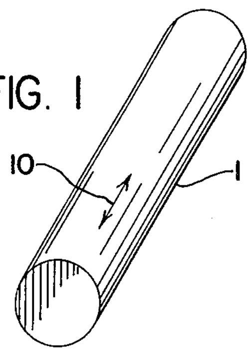

FIG. 2

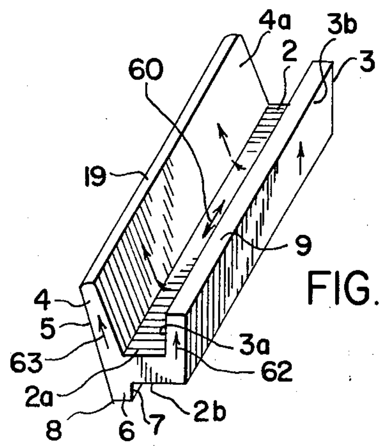

FIG. 3

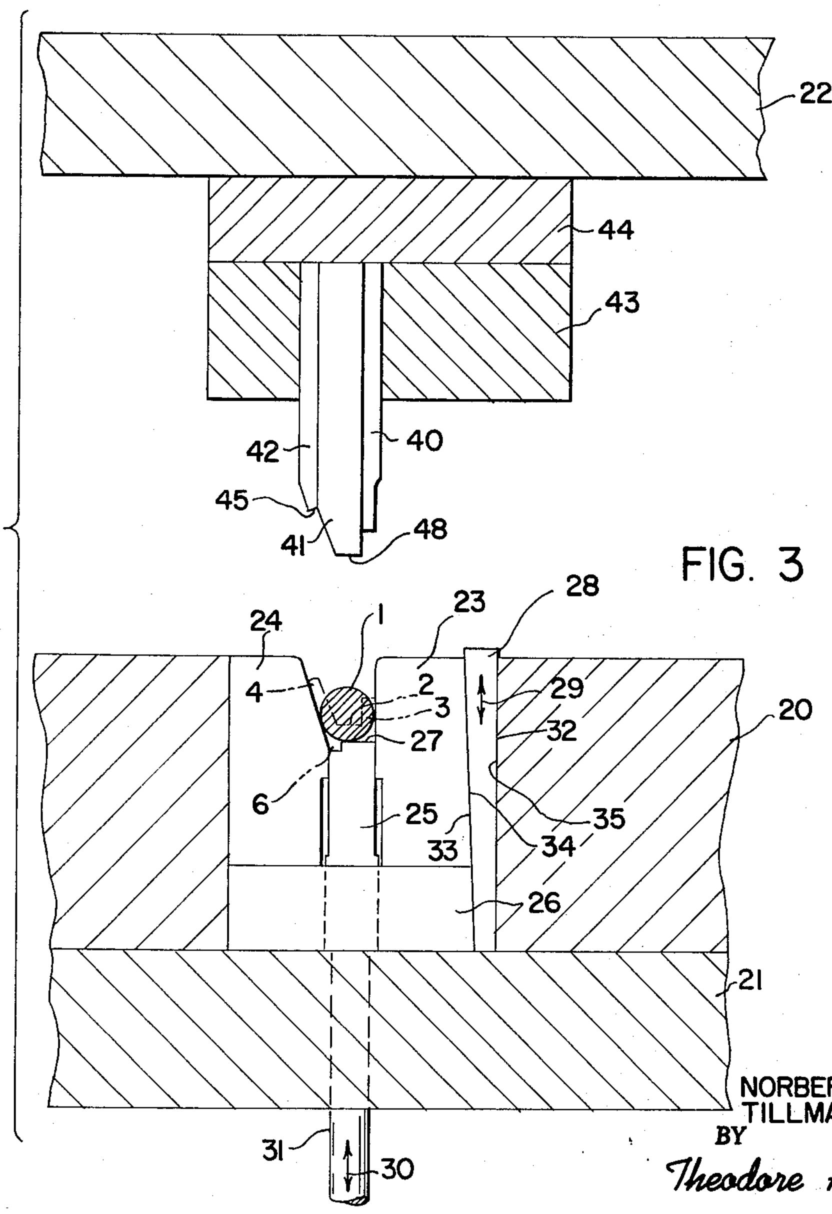

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FIG. 4

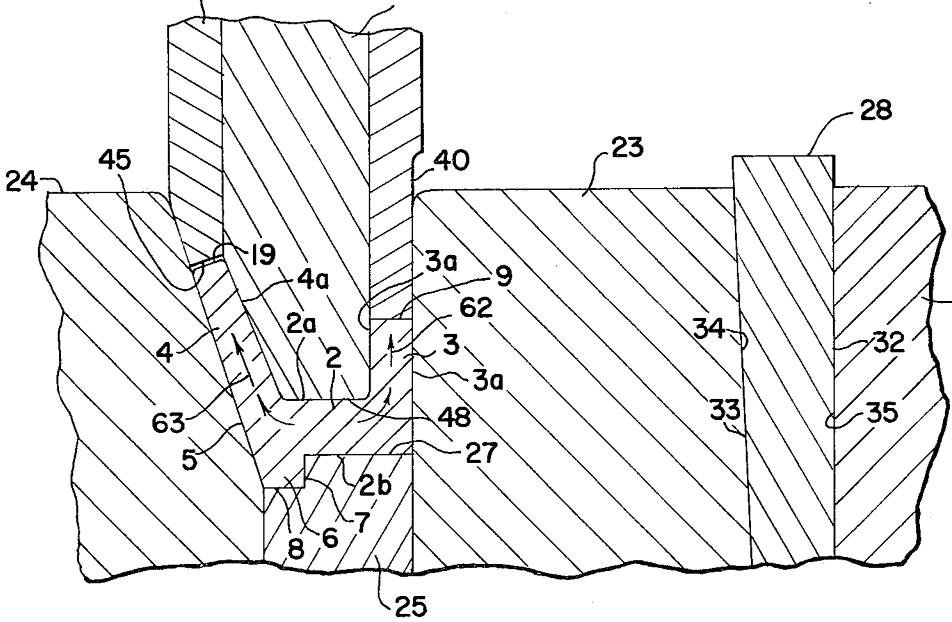
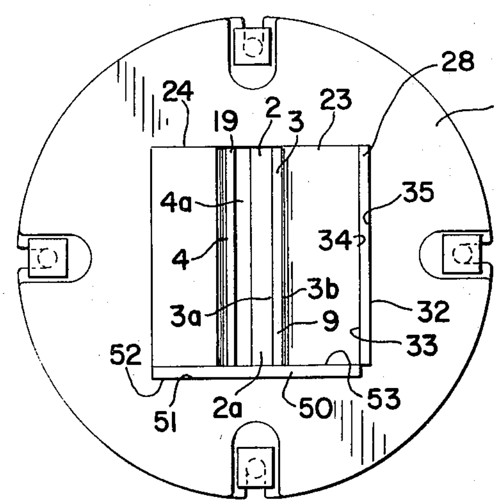


FIG. 5



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COLD EXTRUDED ARTICLE AND METHOD OF MAKING THE SAME

The present invention is directed to a unitary element of disc brakes used on motor vehicles and the like, and to a method of manufacture of such element. It particularly relates to a unitary element of steel in which the metal grains in different portions of the elements are oriented by elongation in different directions so that the high-strength caused by cold work or elongation in a single direction extends in diverse directions at diverse portions of the element.

It is well known that when steel is elongated by cold work the strength of the metal in the direction of the elongation is greatly increased and strength in the metal and direction transverse to the direction of the elongation is somewhat decreased.

In the manufacture of articles of complex shape by a machining process where metal is removed by cutting or milling devices, there is a complete lack of work hardening or toughening and orientation of the metal. In certain machine elements, it is highly desirable for portions of a unitary element to have exceptional strength and toughness in one direction, and for other portions of the element to have exceptional strength in another direction. In a machined article of complex shape, it is customary to compensate for lack of strength of metal in one direction by increasing the thickness and mass thereof. Such increase in thickness causes difficulties in assembly of a complex of elements into minimal space and is accordingly undesirable.

It is an object of the present invention to provide a structural machine element suitable for withstanding the great forces occasionally met with in disc brakes when operated under most severe conditions, in which element the steel in various portions is cold worked to strengthen the metal most greatly in the various directions where strength and abrasion resistance are most important so that a reduction in the mass of the element may be made without reducing the strength in any part.

Another object of the present invention is to provide a method of making a component for disc brakes and the like, wherein portions of the component are work-hardened by elongation in one direction and the other portions of the element are work-hardened by elongation in other directions.

Other objects will apparent from the following description of the invention as illustrated by the appended drawings in which:

FIG. 1 is a perspective view of a portion of a rod used as a source of metal for the production of the machine element.

FIG. 2 is a perspective view of a machine element made from the metal of FIG. 1.

FIG. 3 is an elevational view of portions of a press showing the punch and die elements thereon, and the rod of FIG. 1 in the die and the final article of FIG. 2, outlined by dotted lines.

FIG. 4 is a more enlarged elevational view of the punch and die with the punch in the closed or downwardmost position and the element of FIG. 2 therein.

FIG, 5 is a top-plan view of the die and die holder.

Referring more particularly to the drawings in which like parts are designated by like numerals of reference throughout the several views, the raw machine element for disc brakes as shown particularly in FIG. 2 is generally trough-like in shape having a bottom portion 2, a vertical side portion 3, which is integrally connected to the bottom 2 and is perpendicular to both the planar upper face 2*a* and the planar lower face 2*b* of the bottom portion 2. An opposite side portion 4 extends upwardly and outwardly from the base or bottom 2, the side portion 4 is also integral with the base 2 and with the opposite side portion 3. The plane of the planar inner face 4*a* forms an obtuse angle with the plane of the upper face 2*a* of the bottom 2 so that the sides of the trough are divergent, the trough being narrowest at the bottom.

The outer face 5 of the side 4 is also planar and although it diverges from the wall 3, it diverges less than does the face 4*a*. The first quadrant angle formed by the planes of the outer face 5 and upper face 2*a* is less obtuse than the first quadrant angles formed by the planes of the inner surface 4*a* with the respective planes of the surfaces 2*a* and 2*b* so that the lateral thickness of the side edge 4 is somewhat greater at the point of intersection of the planes of the surfaces 4*a* and 2*a* than at its upper portions. The surfaces 2*a* and 2*b* are required to be parallel and the inner surface 3*a* and the outer surface 3*b* of the side edge 3 are also parallel to permit proper functioning of the brake.

Extending downwardly from the surface 2*b* of the bottom 2 is an integral lip member 5, a portion of which vertically underlies the upper surface 2*a* of the bottom 2. The lip 6 has an inner surface 7 which is perpendicular to the planes of the surfaces 2*a* and 2*b* and intersects with the lower surface 2*b* of the bottom 2. The lower surface 8 of the lip 6 is also planar and parallel with the surfaces 2*a* and 2*b* and with the upper surface 9 of the side edge 3. The outer face of the lip 6 lies in the plane of the outer surface 5 of the side edge 4.

With the exception of the height of the side edge 4, the dimensions of the portions of the brake element of FIG. 2, including each of the faces, their thicknesses and alignment are exceptionally important. The slight variations in the height of the side edge 4 may occur in view of the fact that this is usually further shaped by a machining process as illustrated by a dotted outline FIG. 6.

In the manufacture of the element of FIG. 2, the character and past history of the starting metal is exceptionally important as is also its dimensions, i.e., length and diameter. It is essential that the initial rod 1 be one prepared by rolling or drawing the metal from a thicker mass so that it is extended in a single direction. It may be produced by drawing the metal through a die or rolling it from greater thickness to a smaller diameter so that the elongation of the grains of the metal are in the single longitudinal direction represented by the arrows 10 of FIG. 1. The rod is formed to a definite length and diameter and is coated with a suitable lubricant such as zinc phosphate and a superimposed dry film of soap and borax. Its dimensions are such that it equals the weight of the element of FIG. 2.

In the formation of the complex element of FIG. 2 from a drawn rod so as to provide the desired directional elongation of the metallic grains in various portions thereof, the die both male and female portions thereof, must have particular characteristics to prevent fracture of the die and to also permit removal of the article after it is formed. Referring particularly to FIGS. 3 through 5 inclusive, the die set comprises an outer unitary restraining ring 20 which is mounted on a suitable platen 21, preferably the lower platen of a powerful punch press, having an upper platen 22 movable vertically with respect to the lower platen 21. The press may, for example, be a knuckle-joint press commonly used in coining operations. The restraining ring 20 is of massive construction of high-grade steel so as to withstand tremendous force exerted in generally radial directions during the cold shaping of the metal from the rod portion 1. The restraining ring has a suitably shaped cavity, preferably rectangular shaped in cross section centrally located therein. The cavity preferably extends completely through the angular restraining ring 20. Within the cavity there is disposed the separate female die elements 23, 24 and 25, and the die base 26. The die elements 23, 24 and 25 are shaped to cooperatively provide a cavity corresponding in shape and size (allowing for residual elasticity) to that required to shape the outer surfaces 3*b*, 2*b*, 7, 8 and 5 of the machine element of FIG. 2. The side elements 23 and 24 are forced tightly against the center element 25, the upper face 27 of which forms the bottom surface of the die cavity by suitable die locking means such as the wedge 28 which is movable up and down by suitable means in the direction of the arrows 29, by means (not shown) when the wedge 28 is in the downwardmost position, the contacting faces of the die elements 23, 24 and 25 are pressed and locked tightly together and when the wedge is moved upwardly, the elements may separate slightly so that the element 25 may be moved vertically in the direction of the arrows 30 by means of the knockout element 31, which passes through the platen 21 as shown. The angle formed by the side edges 32 and 33 of the wedge 28 is of necessity a very small angle, i.e., below the critical angle for the friction involved so that the forces incurred during the work on the metal when the male and female positions of the die come together against the metal rod 1 do not permit any upward movement of the wedge 28. An angle of less than 10° generally suffices. The face 32 of the wedge and cooperating face 35 of the restraining ring 20 is most conveniently perpendicular to the plane of the upper face of the platen 21. The face 35 of the die element 23 corresponds to the angle of the face 32 of the wedge 28. When the angle on the wedge 28 is below the critical angle an increase in an outward force perpendicular to the face 35 increases friction against vertical movement of the wedge 28 to a greater extent than it increases the upwardly directed component of the applied force. Means such as the wedge 50 is also provided for controllably locking and facing the female die components relative to endwise movement. The Wedge 50 is similar to the wedge 28 except the face 52 of the wedge 28 and face 51 of the restraining ring 20 are the inclined faces and face 53 is vertical. The wedge 50 is moved vertically to lock and free the die elements 23, 24 and 25.

The male portion of the die is shaped to provide a cross-sectional contour formed by the faces for 2a, 3a and 9 of the brake element of FIG. 2. It may be formed of 3 appropriately held plate-like pieces 40, 41 and 42 respectively, which are tightly fastened in the holder element 43 which is carried through the backup 44 by

the upper platen 22. The male die member may be formed of a unitary element if desired. The face 45 of the male element which would tend to contact the upper surface 19 of the element of FIG. 2 is slightly elevated to provide a clearance for any slight excesses of metal between the surface 19 and the surface 45, otherwise even very minimum variances of the weight of the element 1 will cause fracture of the forming apparatus.

In the formation of the brake element of FIG. 2 the section of the rod 1 cut to approximately the length desired for the element of FIG. 2 and the diameter in size such that the volume or weight of the metal is equal to that required for the element of FIG. 2 as placed in the mold cavity as shown in FIG. 3. It is found to be essential that the initial metal be in the form of the rod section with round or curved surfaces so as to provide initial line contact with the bottom surface 40 of the male die and thus soften the initial impact when the die is brought together. Without the initial line contact a sudden shattering blow occurs that can cause damage to die and forming apparatus. The line contact causes distortion and flow of the metal at relatively low initial pressure and permits a rapid buildup of pressure without shock. The raid continued downward movement causes the metal to flow into the desired shape.

Since the grains of the metal are in the direction of the arrows of FIG. 1, the direction of elongations of metal grains in the formed article will be a composite of the two forming operations. In the bottom at the faces 2*a* and 2*b* where flow of metal has been largely restrained by surface contacts the grain elongation is still largely in the same direction as in the rod 1, i.e., in direction of the arrows 60. The elongation of the metal in the sides 3 and 4 is largely in the direction of the arrows 62 and 63, as illustrated in FIG. 4. It is seen, therefore, that the total elongations is a component of the initial elongation in the rod 1 and the flow shown by the arrows in FIG. 4. This composite flow picture is found to make for exceptional toughness, strength, and wear resistance in the article produced, with the result that lower mass is required for the part. Because of this exceptional cold work and the particular flow directions, it is found that low carbon steels including ordinary 1010 or 1008 steel gives desired properties to the final article that are often even superior to those of an article machined in the ordinary way from expensive alloy steels containing chromium, vanadium and/or molybdenum. The part is produced at a small fraction of prior cost.

The speed with which the metal is required to flow is highly important in the formation of the article. A press with at least 30 strokes per minute and preferably at 40 to 80 strokes per minute produces far superior results than does a slow speed press such as a hydraulic press. Apparently by a rapid flow of the metal the work toughening does not cause resistance of flow to be fully developed until the article is formed; whereas, in a slow operating press the full effects of work hardening occur during the stroke with the result that it becomes very difficult to accurately form the article.

The following example illustrates the invention.

Components for disc brakes having a length of 3 inches and the cross sectional shape of FIG. 2 were required. The components were required to have the following dimensions referring to FIG. 2:

Height of Face 3 above plane of face 2a	–.26"±.002"
Thickness of Base 2	–.28"
Width of Face 2a	–.285"±.005"
Width of Face 26	–.37"±.01"
Height of Rib 6 from Face 2b	–.1035"±.002"
Width of Face 3	–.1580"±.0025"
Angle of Face 4a with Vertical	–22°
Width of lower Face 8 of Rib 6	–.13"±.01"
Width of Face 4a	–.54"±.02"
Thickness of Side 4 at top thereof	–.125"±.005"

The dye was constructed with a cavity of the corresponding dimensions except that the heights of the cavities for forming the sides **3** and **4** and the rib **6** were at maximum and for the thickness of the base **2** at a minimum to allow for the elastic shrinkage due to the attempt of the metal to return to its initial state. The die set was appropriately fastened to the platens of a 1,500 ton press having about 40 strokes per minute. Rods of 1010 or 1008 steel having a length of 2.992 inches to 2.988 inches and a diameter of 0.665 inches were centerless ground to a diameter of 0.553 to 0.555 inch. A ground rod thus prepared was phosphate coated with a zinc phosphate to provide a base coat, then dipped into a solution of soap and borax as described in U.S. Pat No. RE 24,017, and placed into the die cavity and the press operated. The formed piece had the required dimensions and the desirable physical properties previously had only with expensive alloy steels.

The process was repeated hundreds of times without damaging the forming apparatus.

While it is found that the low carbon steels are so upgraded by the particular character of cold flow and cold work that they may be used in place of components before made by machining expensive alloy steels, it is of course permissable to substitute other steels including various stainless steels, for example the customary 18–8 variety, for the low carbon steel. The blank or rod used should have substantially the same dimensions regardless of steel used, and the properties of the article will be similarly upgraded from the product machined, made by machining a block of the steel.

It will be understood that in accordance with the provisions of the patent statutes, modifications of the construction shown may be resorted to without departing from the spirit of this invention.

I claim:

1. In a process of cold forming a unitary one piece steel component for the disc brakes of motor vehicles which component has a generally U-shaped cross-section having a base with upper and lower substantially parallel planar surfaces, a first side extending vertically upwardly from one side of said base, said first side having inner and outer planar substantially parallel surfaces, the inner face extending from the upper planar surface of the base, a second side having inner and outer planar surfaces, the inner planar surface extending upwardly and outwardly from a side of the upper surface of said base and diverging from said inner surface of said first side member, the outer surface of said second side forming a smaller first quadrant angle with the planes of the bottom than the corresponding angles formed by said planes and the inner surface of said second side, a lower lip extending from one side edge thereof extending vertically downward from one side edge of the bottom surface of said base and the opposite side edge thereof in the plane of the planar outer surface of the said second side, the lower surface of said lip, the upper surface of the said first side being planar and parallel to the said upper and lower surfaces of the bottom, portions of said component having closely controlled dimensions; the steps which comprise forming a rod portion of axially elongated steel having uniform cross section, a weight equal to that of the desired cold formed component and a smooth clean curvilinear surface, applying to the surface an integral coating comprising of a member of the group consisting of zinc and manganese phosphates, superimposing thereon a suitable dry film lubricant comprising a soap and meltable pigment, placing said thus coated rod in the cavity of a female portion of a die mounted on a platen of a forming press and having inner wall portions substantially corresponding to the outer surfaces of the desired component, said rod being placed in said die horizontally with respect to the direction of stroke of the forming press and applying forming pressure against the metal in said die cavity through a male die component having an outer surface portion corresponding in dimensions and shape to the inner surfaces of the desired component, said pressure being applied by a mechanically operated press having at least 30 strokes per minute, initial deforming pressure being made only along lines in the curved surface of said rod portion where contact is made between a plane surface of said die and said rod, whereby the shock due to impact is reduced and the metal is formed at a rate such that effect of work hardening is reduced during the period of metal flow.

2. The process of claim **1**, wherein the axially elongated rod portions are cylindrically shaped and the deformation from cylindrical shape is made a rate of movement of the ram of the press operating at 40 to 80 strokes per minute.

3. The process of claim **1** wherein the said rod is of low carbon steel.

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