

June 3, 1952

A. B. WHITE
METHOD OF AND MEANS FOR UPSETTING
SHAFTS AND THE LIKE

2,598,868

Filed Oct. 12, 1949

3 Sheets-Sheet 1

FIG. 1

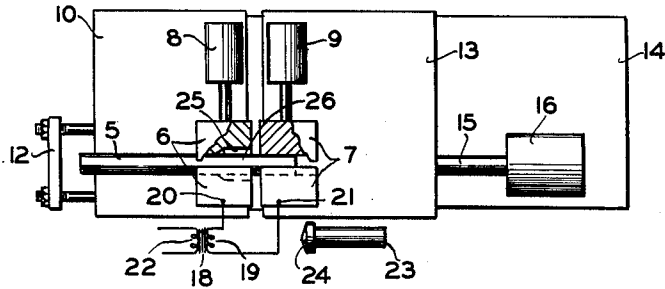


FIG. 2

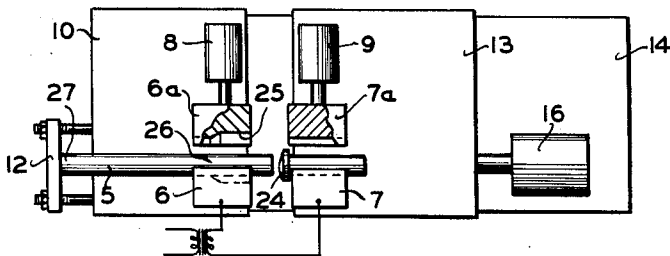


FIG. 3

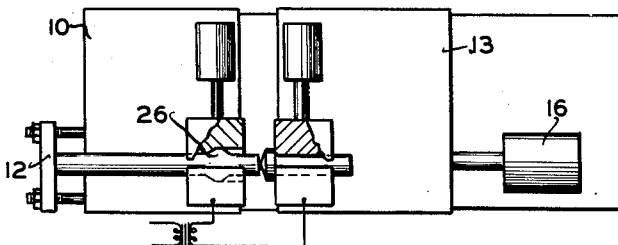
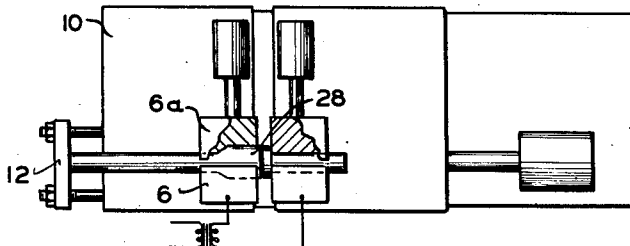


FIG. 4



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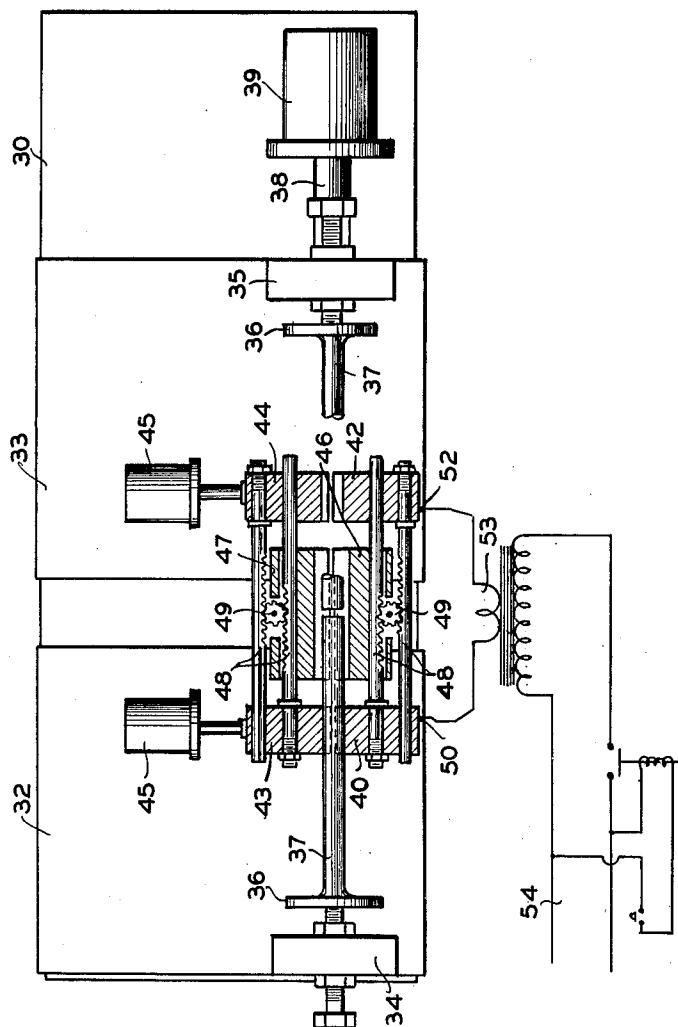
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FIG. 5



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FIG. 6A

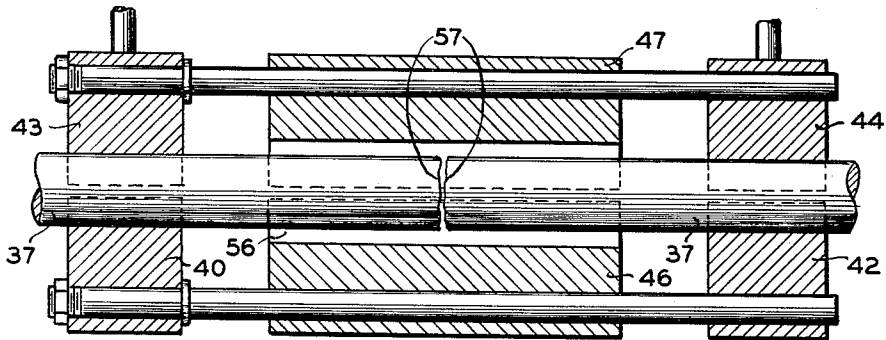


FIG. 6B

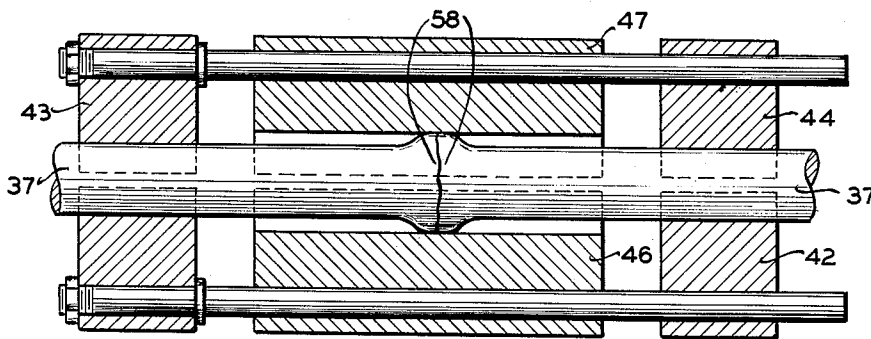
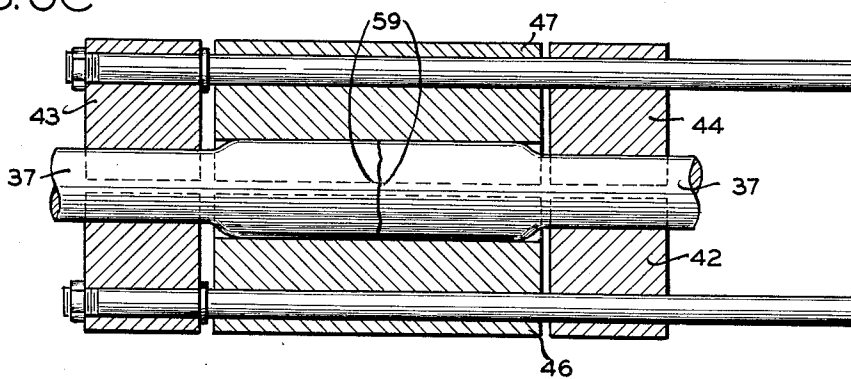


FIG. 6C



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UNITED STATES PATENT OFFICE

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6 Claims. (Cl. 219—3)

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This invention relates to a method of and means for forming upsets of shafts and the like and, more particularly, is concerned with an electro-forge method of making shaft upsets.

Heretofore, axle shafts and similar products requiring upsets at one or both ends thereof for the machining of splines or forming of collars, etc., have usually been fabricated by first heating the portion to be upset in a furnace of one type or the other, to a forging temperature and then transferring the heated piece to a bulldozer or upsetting machine to apply pressure to the heated metal in a suitable die cavity to form the desired upset.

This method has been objectionable from the standpoint of loss of material due to the formation of scale and carburization, and to the fact that uniformity of grain structure is not always provided by a two-step operation of this type. Furthermore, the attendant smoke and heat creates an unpleasant working condition for those employees operating the furnaces and upsetting machines.

The present process has as its primary object to provide a method of and means for forming splines or bosses on shafts by an electro-forge process which results in a product of improved quality. Along with this, the present process also has the advantage of requiring less material to form the upset due to the elimination of scale and carburization of the surface of the shaft, so that an appreciable saving in the amount of material required is attained.

Still a further feature of the present invention is to provide a process for forming such upsets whereby they will be formed progressively, thereby producing much better control of the shape, as well as saving material and labor and reducing the effects of heating prevalent in furnace type operations.

Still another advantage attained by the present process is the provision of better working conditions during the operations, thereby increasing the efficiency of the worker and reducing, or altogether eliminating, attendant smoke and bad atmospheric conditions usually prevalent around furnaces and upsetting machines.

The process is also adaptable to the formation of upsets or bosses on two shafts simultaneously, thus further reducing the labor, power and die costs per shaft.

In order to perform the present process, the equipment used basically consists of resistance welding equipment comprising a stationary and a movable die, each connected to one side of the secondary circuit of a transformer or other source of electric power capable of handling relatively high currents at low voltage. In such an arrangement, the movable dies are so disposed as to be forced toward the stationary dies by any

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suitable means, such as a hydraulic cylinder and piston arrangement or the like, which will produce a relatively large upsetting force.

While such equipment may take many forms, a flash welder or resistance butt-welder appears to be the most desirable type of machine tool to be employed because the dies in such equipment are in the form of clamps which are readily adaptable for gripping shafts or the like.

Using this method of electro-forging for the formation of spline end bosses on axle shafts, as well as other upset portions on shafts, such as oil seal collars or flanges, produces an improved product by virtue of the rapid heating and forming operation which are conducted substantially simultaneously. In previous methods utilizing furnace heating or the like, the surface of the shaft and the portion to be upset becomes badly oxidized unless extensive and elaborate precautions are taken. As a result a heavy scale is produced. This, in turn, collects in the forming dies in the upset operation, causing pits or malformation of the shaft surface and boss.

Furthermore, the metal under the scale is badly decarburized and may possibly be burned. Because of these factors, the boss must be considerably larger than the finish size required, and the pitted, decarburized, and burned material must be machined away. Also, in all such cases, since the heat necessary to bring that portion of the shaft which is to be upset or forged to a forging temperature also heats adjacent ancillary portions of the shaft and extends into the portion of the shaft not upset, the shaft itself may usually be reduced in size and strength by the scaling, decarburization, and burning effected in the furnace.

In the electro-forge process, these factors are almost entirely eliminated. The boss or upset portion to be formed may be made substantially to finish size, saving considerable material as well as the labor required in machining excess material away. Furthermore, the shaft near the boss is neither reduced in size nor is the material changed in structure, so that a stronger shaft is produced.

In the operation of the present process, when a portion of the shaft, not at its end, is to be upset, the shaft may be gripped by the clamping dies so that this portion lies between the moving and the stationary dies. As the potential of the power source is applied to the dies, as by energization of the transformer, a high current flows through that portion of the shaft lying between the dies and which is not contacted by the die material. As a result, this portion of the shaft is heated by the electrical resistance of the shaft material and by the electrical contact resistance between the dies and the shaft.

However, since the clamping dies which also

act as electrodes conduct heat from the shaft, that portion between the dies heats much more rapidly and reduces the strength of the metal. As the temperature is increased until the metal is at a forging state, axial force may then be applied to the moving die to form the upset on the shaft to the desired degree.

When an upset is to be formed at the end of the shaft, the shaft may be clamped in one of the clamping dies and butted against a header die which also acts as a current contact and which is carried on the movable die support.

It is also possible to employ auxiliary dies coming in from the sides to confine the material in the shaft which is heated to the forging temperature to the desired shape as it is upset.

One of the main features of the present process resides in the fact that the upset is formed progressively by the gradient in temperature in the forging of the shaft to be upset, so that a progressive flow of metal is produced, effecting filling of the die cavity without requiring any sliding or frictional contact of the metal in the upset direction within the die. This avoids any possible malformation of the die surface, producing the desired filling of the die cavity in a progressive manner under positive control, so that the flow lines of the grain of the material will follow a natural path, giving a much better grain formation in the upset portion, adding to the strength of the product. The die life, of course, is materially improved over that of the normal dies in an upsetting machine.

In order to illustrate the present process and means for carrying out such a process, I have illustrated two ways in which upsets for the spline ends of axle shafts may be formed and a detail description of these two methods with particular reference to the accompanying drawings illustrating the same, will disclose to those skilled in the art, the particular method and means for carrying out the present process.

In the drawings, Figures 1 to 4 inclusive, are diagrammatic showings of an electro-forge method of forming a spline upset in the end of a shaft, Figure 1 showing the initial setup and heating of the equipment for the preliminary heating operation, Figure 2 showing the final clamping position, and Figures 3 and 4 disclosing the upsetting and heating operation in the initial and final stages;

Figure 5 is a diagrammatic showing of a modified construction wherein two axle shafts are to be upset simultaneously; and

Figures 6A, 6B, and 6C are detail showings of the clamping dies and forming die utilized in connection with the equipment shown in Figure 5.

Considering now in detail the process and means for carrying out the same disclosed in Figures 1 to 4, these illustrate the formation of a spline end boss on an axle shaft where it is particularly desirable that the junction between the shaft and the boss have a definite shape and be a predetermined distance from the end of the shaft.

As illustrated in these figures, the shaft 5 is gripped in a pair of split die members, indicated generally at 6 and 7, the die members 6 and 7 each being adapted to be moved into clamping engagement with the shaft by means of clamping cylinders 8 and 9, respectively, the die 6 and clamping cylinder 8 being carried upon a stationary platen 10 mounted upon the bed or support for the machine. This platen also carries an adjustable stop member 12 at one side thereof

for a purpose to be described in detail hereinafter.

The dies 7 and their accompanying actuating cylinder 9 are carried upon a movable platen 13, mounted in suitable ways upon the machine bed 14 and adapted to be moved toward and away from the stationary dies 6 by means of the hydraulically controlled piston rod 15, actuated through the hydraulic cylinder 16.

A transformer is indicated generally at 18 and the secondary side thereof, indicated at 19, has connection to the die members 6 and 7, as indicated respectively at 20 and 21. The primary of the transformer, indicated at 22, is connected to any suitable source of power supply.

A header member 23, having a conical or frusto-conical head portion 24 is also provided, as will be described hereinafter.

In the position of the equipment shown in Figure 1, when the transformer is energized current flows from the dies 6 through their contact about the surface of shaft 7 into the shaft, and thence out to the opposite side of the transformer through the contact of this shaft end with the dies 7. It will be noted that the dies 6 are so formed as to provide a die cavity 25 through which the shaft, under normal conditions, extends without any contact. Due to the voltage imposed on the shaft and the inherent resistance of the shaft material, the portion of the shaft out of contact with the dies, as indicated at 26 in Figure 1, becomes heated. As the temperature of this portion of the shaft at 26 approaches forging temperature, the movable portions of the dies 6a and 7a respectively, as shown in Figure 2, are pulled away and the shaft is moved to the left with its end 27 abutting against the stop member 12.

The header 23 is then inserted into the dies 7 and the dies reclamped about the shaft and the header member. As the movable platen 13 then moves toward the end of the shaft 5 contact is made with the conical end portion of the header to continue the current flow through the shaft. It will be noted that the heated portion 26 of the shaft at this time is partially clamped in the dies 6 which rapidly cool that portion in contact with the dies. However, progressive heat continues from that point on out through the die cavity 25 to the end of the shaft which is in contact with the header end 24.

The purpose of the reduced area of contact between the header and the end of the shaft is to increase the resistance at this point so as to provide more effective heating of this portion of the shaft. As shown in Figure 3, further movement of the movable platen 13 toward the stationary platen 10 results in initial upsetting of that portion of the shaft, indicated at 26, which had been preliminarily heated and which continued to be heated during the application of current after the end of the shaft was contacted by the header 24.

Thus it will be seen that the initial upset occurs at the junction between the shaft and the portion where the boss is to be formed, this metal being sufficiently soft to flow out and completely fill the die cavity. The heating progressively continues on toward the end of the shaft, the portion 26 which was initially upset immediately cooling, upon contact with the walls of the die cavity so that a progressive forging operation from this juncture point on out to the end of the shaft is provided, providing a progressive upsetting of the soft material in the desired direc-

tion to insure complete filling of the rear or inner approach of this die cavity and preserving proper grain flow lines in the shaft material.

The complete upset is shown in Figure 4, with the die cavity filled and the shaft end 28 being the only point now heated, since this end is the only portion of the shaft projecting beyond contact with the dies 6.

It will thus be apparent that with this type of forge operation a progressive heating and simultaneous forging of the material takes place, insuring complete filling of the die cavity without requiring unduly high pressure and retaining the proper grain flow lines, the upset material immediately being cooled as it moves into contact with the surfaces of the die cavity. This produces a finished axle shaft of substantially the desired dimensions which requires no machining to remove scale and decarburized material or the like, and thus materially reduces the amount of material necessary to form the upset, thus allowing the same diameter upset to be formed with less axial length of shaft material.

As pointed out heretofore, the purpose of making the end 24 of the header 23 either frustoconical or conical in shape is to reduce the area of contact which thereby increases the electrical contact resistance and, consequently, accelerates the heating of the blank. It also reduces the heat conduction to the header so that the end of the shaft may more readily and easily fill the end of the die cavity.

Another purpose of the conical shape of the header is to provide a straight line thrust on the center line of the shaft in order that a straight axial position may be provided in cases where the end of the shaft may not be square which is often the case with sheared stock.

Considering now Figures 5 and 6A to 6C, these illustrate another example of a progressive upset and, primarily, are for the purpose of illustrating a method of carrying out the present process whereby two shafts may be upset simultaneously. In this case, it is also true that the overall length of the shaft is more important than the distance to the start of the boss.

As described previously, the hottest zone in this type of operation is produced at one end of the upset portion, and the heating and the upset are progressive until the cavity is filled as desired.

The machine bed is illustrated at 30 and includes a stationary platen 32 and a guided movable platen 33. Each of the platens is provided with adjustable stops 34 and 35, respectively, against which the flanged ends 36 of axle shafts 37 are located. The movable platen is adapted to be moved toward or away from the stationary platen by means of the piston 38 and the hydraulic cylinder 39.

Mounted on each of the platens are die members 40 and 42, respectively, in the form of split dies, having movable die portions 43 and 44, respectively, adapted to be moved toward and away from the stationary portions of the dies by the hydraulic cylinders 45.

It will be noted that the shafts are clamped by the die members intermediate their ends and have the free end portions thereof extending toward each other substantially into abutting engagement and located within a forming die 46, having the movable die portion 47 and having a die cavity substantially of an internal diameter equal to the external diameter of the bosses to be formed on the ends of the axle shafts. The

forming die 46—47 is arranged for movement in direct proportion to the movement of the movable platen 33 by means of the rack and pinion arrangements, indicated generally at 48 and 49, whereby the forming die moves toward the stationary die 40 at a rate equal to one-half of the rate of movement of the movable die 42. If desired, the forming die could be a floating die for this purpose.

The transformer connections to the dies are indicated at 50 and 52, leading from the secondary 53 of the transformer, the primary of which is connected to a power line, indicated generally at 54.

Considering Figures 6A through 6C inclusive, which are detailed diagrammatic views of the stationary dies and floating die or forming die, Figure 6A illustrates the initial position of the die mechanisms with respect to the axle shafts when the secondary of the transformer is energized. It will be noted that at this time the ends of the shafts are spaced out of engagement with the die cavity 56 and, preferably, are in just sufficient contact to provide for transmission of current therethrough. This provides for heating those portions of the shafts between the dies 40 and 42 to a forging heat. Pressure is applied to the cylinder 39 to bring the shaft ends into contact, since the ends of the shafts may be separated initially to facilitate loading of the mechanism. Upon energization of the transformer secondary 53, current flows from the stationary dies through the shafts to the moving dies. Since the contact between the shafts is the point of greatest electrical resistance, the ends of the shaft, indicated at 57, will heat much more rapidly so that this portion of the shafts becomes hottest. The heat at these ends might be intensified by reducing the area of contact as by beveling or the like, although the rough sheared ends usually encountered produce sufficient lack of contact to provide the greatest electrical resistance and thereby produce the desired result of heating the adjacent ends of the shafts first.

This contact resistance might also be increased by reducing the pressure of the upsetting cylinder. It also may be desired to increase the contact resistance and also to facilitate separation of the shafts by coating the ends of the shafts with a high resistance layer of material, such as a mixture of finely divided aluminum oxide, graphite, or metal powder. This also reduces the tendency for a pressure weld to be formed between the ends of the shafts.

After the adjacent ends of the shafts have been preheated to a higher temperature than the rest of the shafts, the upset pressure may be gradually increased, while the electrical heating continues. Since the ends are the hottest portions of the shaft, they will upset and fill the cavity first, as shown in Figure 6B at reference numeral 58.

The auxiliary center dies are preferably formed of a conducting material which serves to both cool the upset metal as it comes into contact with the inner surface of the die cavity and to shunt part of the current around the upset portion. Thereafter the upset continues progressively as described previously in conjunction with Figures 3 and 4, along each shaft from the end thereof until the cavity is filled to the desired amount. This portion of the upset is shown in Figure 6C, where upset bosses 59 are shown as having been formed along a substantial portion adjacent the ends of the shaft, sub-

stantially filling the die cavity of the die 46—47, while the movable dies 42—44 have been moved into close proximity to the forming die which, in turn, has moved into close proximity to the stationary die 40—43.

I have shown the cavity in the auxiliary or center forming die as having a cylindrical bore. This will produce the boss shape usually desired for spline ends of shafts. Furthermore, the junction between the shaft and the boss will have the desired gradual taper free of sharp corners and with the proper grain flow in the material. It is obvious, however, that the cavity of the forming die may have other shapes and that part or all of the cavity might be formed in the clamping dies in order to produce more complicated or more exact boss shapes.

The two-shaft method described and illustrated in Figures 5 and 6, produces results equivalent to the single shaft method so far as metallurgical and physical structures are concerned, with only a slight increase in labor and time. Power requirements are not increased appreciably and may even be reduced because of the fact that there is less opportunity for the dies to conduct away the heat developed in the shafts.

Also, it will be apparent that die costs are reduced, since only one die is required for forming both upset bosses. Separate clamping and forming dies are desirable, and simple inserts may be provided for these dies to accommodate a range of sizes separately in the shaft and boss. The header die 23, as described in connection with Figures 1 to 4, is eliminated since the shaft ends each act as a header die for the opposing shaft.

In certain cases, it may be desirable to minimize oxidation still more than is effected by the rapid heating and cooling of the electro-forging method. This can be accomplished by surrounding the heated zone by a protective atmosphere, such as hydrogen or one of the inert gases.

It will be apparent from the foregoing description that I have provided for an improved electro-forging process for forming bosses or upsets on shafts or the like, including reducing the time and temperature required for the operation and increasing die life and attaining a better control of shape and grain flow. The present process also is a considerable improvement over the previous progressive heating, forming and cooling, in that it eliminates oxidation and scaling, thus requiring a lesser amount of material to form the upset and also requiring less machining operations to finally finish the boss. This reduces the labor, power and die costs per shaft. One further advantage attained is that the working conditions and worker efficiency are considerably improved by the elimination of smoke and heat in the working area.

I am aware that the present disclosure is illustrative of only one form which the present process may take, and I therefore do not intend to be limited to the exact details herein shown and described, but only insofar as defined by the scope and spirit of the appended claims.

I claim:

1. The method of upsetting an end portion of a shaft which comprises initially passing an electric current through a portion of said shaft adjacent said end, then passing an electric current through said shaft end to heat both said portions, and axially compressing said heated portions to form an initial upset at said first heated

portion and thereafter continuing said upset to the end of said shaft.

2. In the method of forming an elongated upset on a shaft end, the steps of electrically heating said end progressively from the point at which the initial upset is to be formed to the end of said shaft, and axially compressing said shaft to progressively upset the same in accordance with the direction of the heat gradient produced therein.

3. A method of forming similar upsets on the adjacent ends of a pair of coaxially aligned shafts which comprises clamping each of the shafts at a point adjacent to the end portions to be upset in electrodes and enclosing said portions within a forming die floating between said electrodes, electrically heating said portions between said electrodes to a forging temperature, moving at least one of said electrodes to apply axial pressure to said heated portions for upsetting the same, and conducting heat progressively away from said portions as they upset into contact with said forming die.

4. In a combination heating and upsetting mechanism, a stationary platen, a movable platen, means for clamping a pair of shafts in axially aligned end to end position on said platens including an electrode on each platen, means for passing electric current from one electrode to the other through the portions of said shafts between said electrodes to heat said portions to forging temperature, a forming die encircling said portions between said electrodes and including a die cavity having a diameter equal to the desired upset diameter of said shaft portions, and means for moving one platen toward the other to apply axial pressure to said shaft portions to upset the same into said cavity.

5. The mechanism of claim 4 including means for moving said forming die at a rate proportionate to the movement of said platen.

6. A method of forming similar upsets on the adjacent ends of a pair of coaxially aligned shafts which comprises coating the ends of said shafts with a high resistance layer of material, clamping each of the shafts at a point adjacent to the end portions to be upset in electrodes, electrically heating said portions between said electrodes to a forging temperature, and then moving at least one of said electrodes to apply axial pressure to said heated portions for upsetting the same.

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