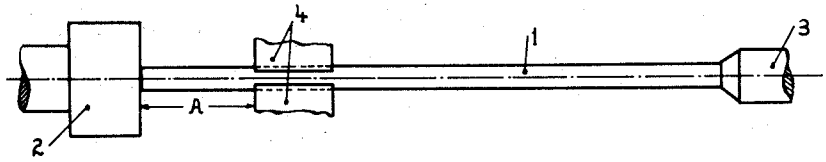
Aug. 5, 1930. E. GIACCHINO 1,772,444

APPARATUS AND METHOD FOR FORGING AND ROUGHING OUT IRON AND STEEL BARS BY ELECTRICITY

Filed Oct. 10, 1927 5 Sheets-Sheet 1

Fig. 1



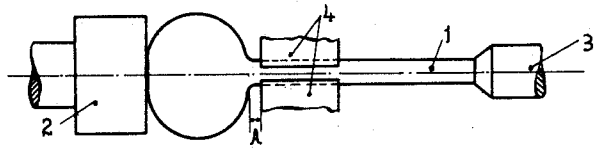


Fig. 2

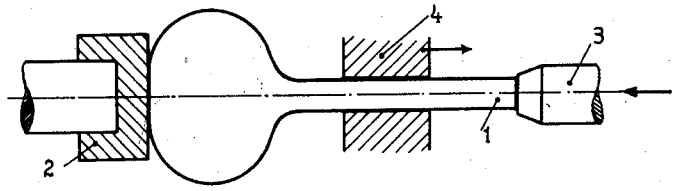


Fig. 3

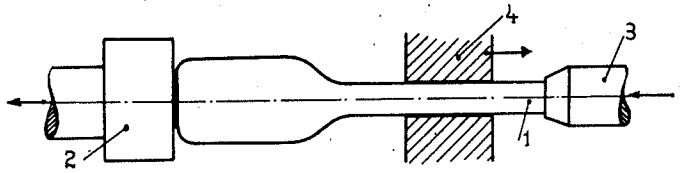


Fig. 4

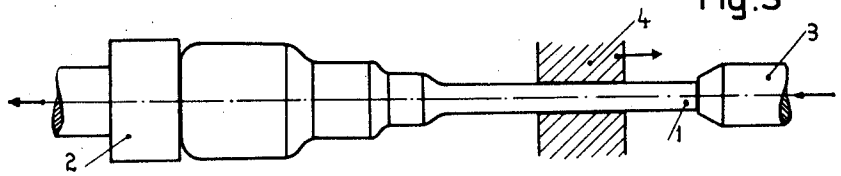


Fig. 5

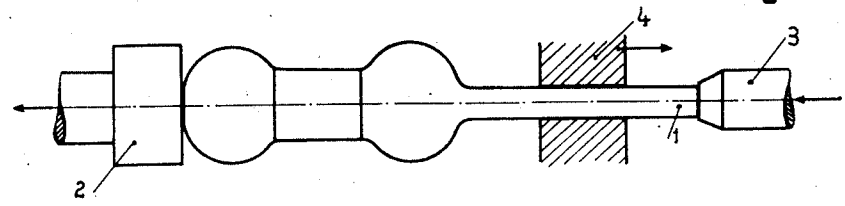


Fig. 6

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APPARATUS AND METHOD FOR FORGING AND ROUGHING OUT IRON AND STEEL BARS BY ELECTRICITY

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Fig. 7

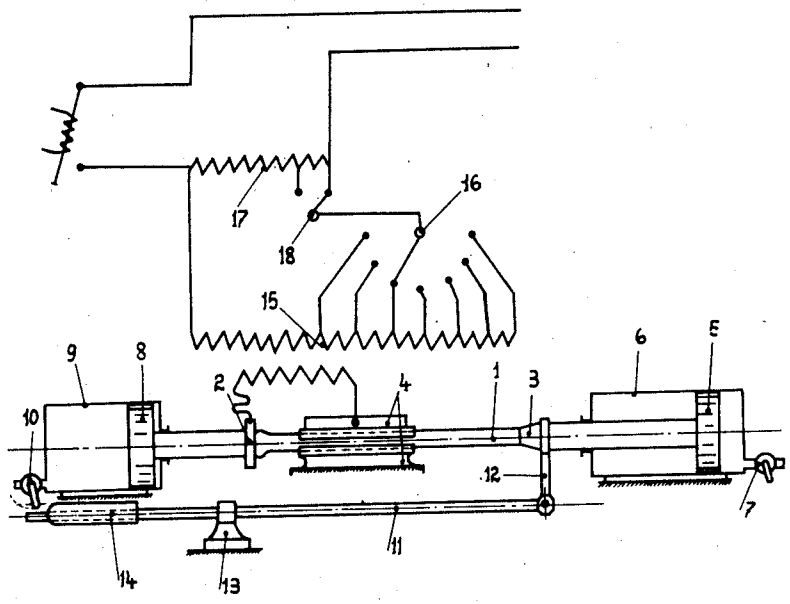


Fig. 8

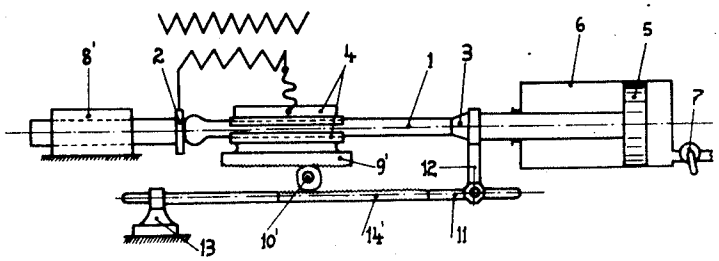
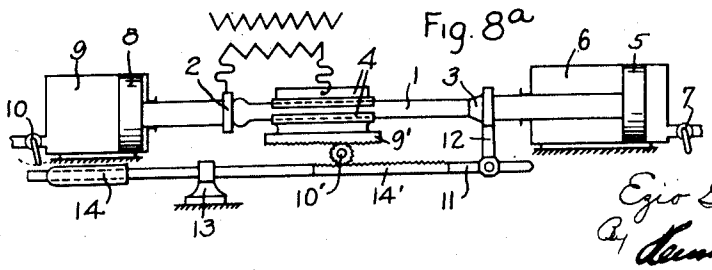


Fig. 8a



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APPARATUS AND METHOD FOR FORGING AND ROUGHING OUT IRON AND STEEL BARS BY ELECTRICITY

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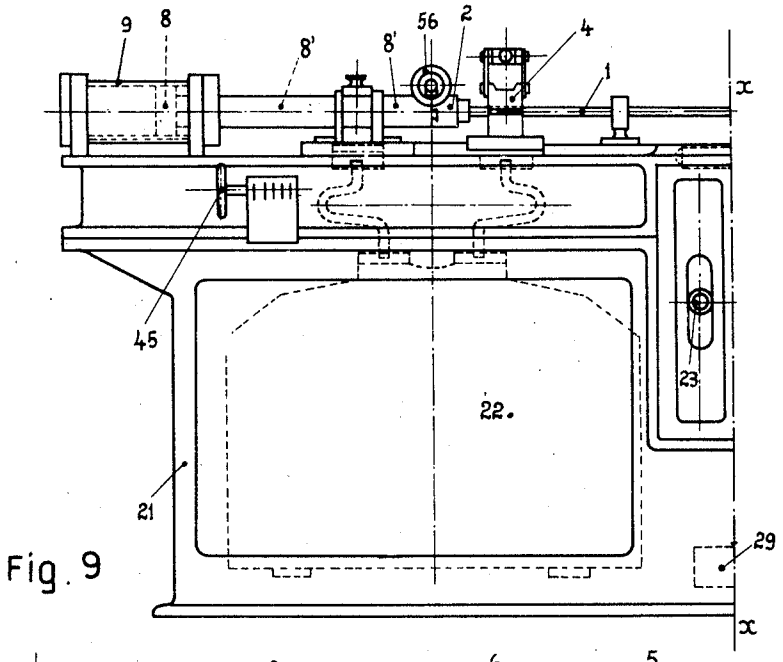
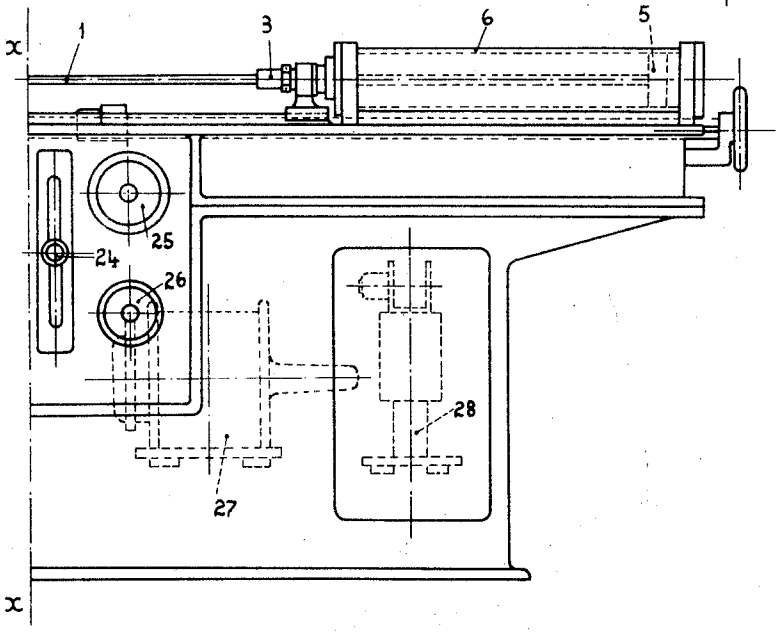


Fig. 9



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APPARATUS AND METHOD FOR FORGING AND ROUGHING OUT IRON AND STEEL BARS BY ELECTRICITY

Filed Oct. 10, 1927 5 Sheets-Sheet 4

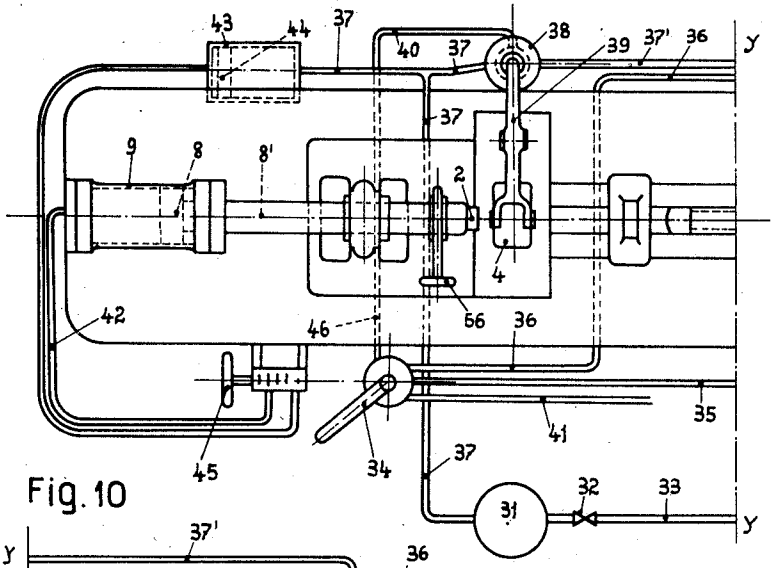
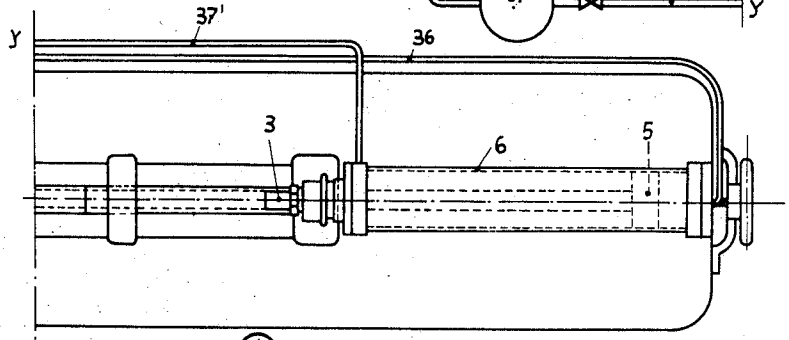
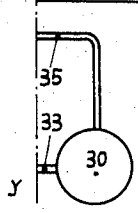


Fig. 10





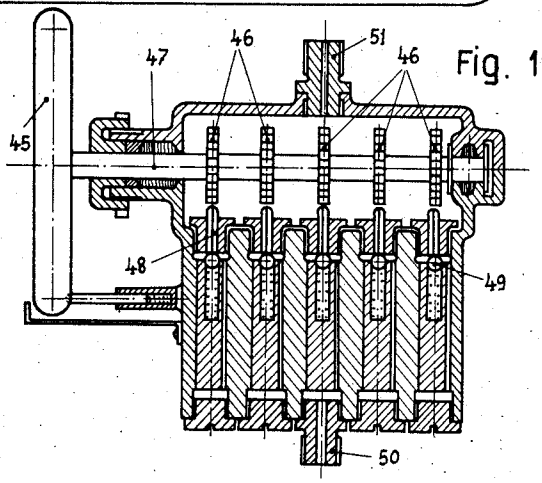
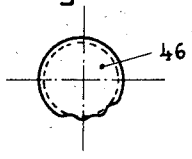


Fig. 11

Fig. 11a



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APPARATUS AND METHOD FOR FORGING AND ROUGHING OUT IRON AND STEEL BARS BY ELECTRICITY

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Fig. 12

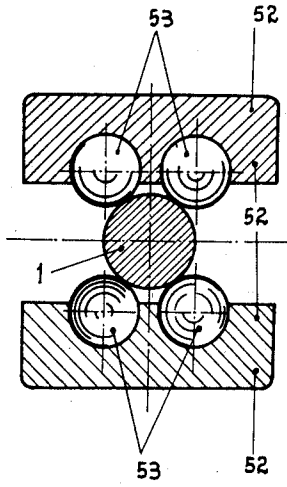


Fig. 13

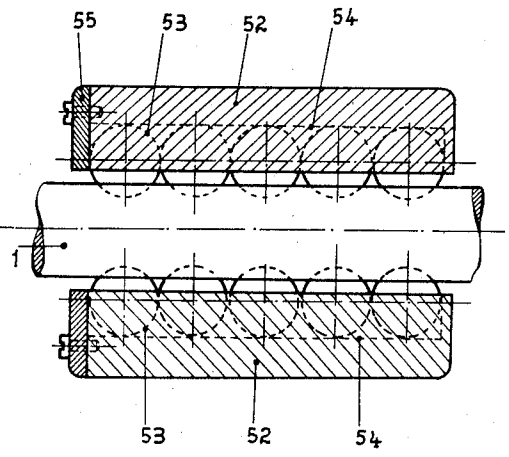
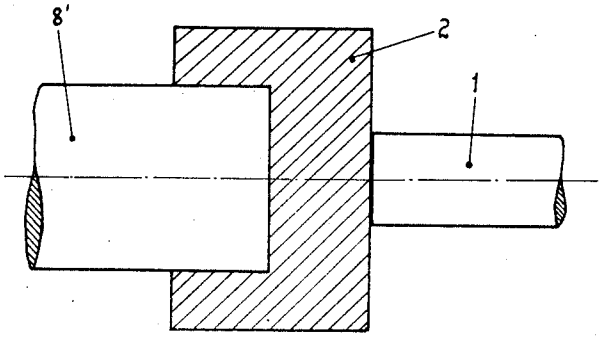


Fig. 14



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Patented Aug. 5, 1930 1,772,444

UNITED STATES PATENT OFFICE

EZIO GIACCHINO, OF TURIN, ITALY, ASSIGNOR TO SOCIETE HOLDING DES BREVETS ET PROCEDES GIACCHINO POUR L'EBAUCHAGE ELECTRIQUE, SOCIETE ANONYME, OF GENEVA, SWITZERLAND

APPARATUS AND METHOD FOR FORGING AND ROUGHING OUT IRON AND STEEL BARS BY ELECTRICITY

Application filed October 10, 1927, Serial No. 225,232, and in Italy November 9, 1926.

It has been proposed to forge by electricity iron and steel bars by heating them through the electric current by the Joule effect and apparatus have been devised for carrying out said process.

Such apparatus consist chiefly of two distinct parts:

1. An electrical part delivering the alternating current of the required intensity for heating the bar,

2. A mechanical part comprising members for transmitting to the bar heated by the electric current the necessary pressure against a stop member serving as anvil in order to deform and thereby forge the work piece.

The mechanical members are chiefly a stop member (anvil) this being one electrode, against which the bar is pressed for forging; a guide member for the bar, this being the other electrode working with a sliding contact and a pressure device acting upon the bar in order to produce its deformation in the heated zone.

The electrodes have received heretofore a number of different forms; the latest machines are fitted with an electrode serving as anvil provided with adjusting and centering means in order to fix its position exactly with respect to the other electrode before beginning the forging process and with an electrode guiding the bar comprising smooth bearings which must fit exactly the work piece on which they are closed with a certain pressure, the bar sliding in said bearings with a sliding friction when its is pressed against the former electrode.

During the forging process both electrodes are unmovable one with respect to the other and forging takes place by the formation of a bulb having approximately the shape of an ellipsoid of revolution, the largest possible size of said bulb is limited by the distance previously determined between the electrodes, this distance being always rather small in order to avoid any lateral bending of the bar.

In these machines provided with the last improvements devised heretofore, the forged portion has constantly the shape of an ellipsoid of revolution, which is the only one attainable as the bar is pushed against a stationary anvil at the point of contact with which the heating of the material begins; the metal deforming itself permanently by spreading on the anvil surface and acquiring the well known characteristic shape.

In the known machines it is of course possible to keep the bar stationary and to move both electrodes simultaneously maintaining their relative distance unaltered, the result, however, would be unchanged.

By these machines it is not possible to forge large pieces nor to exceed certain limits in the ratio between the mass of upset metal and the bar size, as the temperature of the work piece in the forging zone rises rapidly till the metal burns and the bulb of upset material becomes detached; the distance between the electrods, which is unvariable during work, cannot be but very small as the bar to be upset would otherwise (as above stated) bend under the end load and the forged piece would be excentric.

Even working within the above mentioned narrow limits admissible in such machines, great care must be taken in order to avoid burning of the work piece especially when forging special steel as the known processes and apparatus do not allow of an easy and reliable regulation of the upsetting temperature and pressure.

This invention relates to a machine for electrically forging iron and steel which obviates the said disadvantages and allows of forging large pieces and upsetting large volumes of metal with respect to the bar size; further to obtain jolted pieces of any form, either cylindrical or conical or having an outline formed by any broken line, this being of the utmost importance as it becomes possible to effect in any kind of work an actual roughing out of the piece which has never been obtained by the machines of the prior art.

According to this invention, during the forging process the distance between the electrodes is increased until the heating circuit is broken, which allows, as shown hereinafter, to work in a reliable manner even large pieces and to upset large volumes of metal with respect to the bar size, not exceeding in any case the dangerous temperature limit

for a good execution of the work even if this is prolonged for a certain length of time.

This result can be obtained either by displacing the guide electrode in a direction opposite to that in which the bar advances or by moving the other electrode working as the anvil or abutment in the same direction as that in which the bar advances but of course at a lower speed, or by effecting both movements at the same time.

The displacement of the electrode working as the anvil or abutment allows moreover of roughing out the piece, i. e. to obtain a forged piece of any desired profile. To this purpose one has only to vary the speed of the backward motion of the anvil in order to obtain corresponding variations in the profile of the forged piece; to a constant backward speed corresponds a cylindrical upsetting; to a gradually increasing speed corresponds a conical profile; by varying during work the backward speed of the anvil the shape of the profile of the bar section upset in the corresponding period of time is varied and as the speed range of the anvil between nought and a speed equal to that of the forward movement of the bar is a very wide one, there will be an endless number of variations of the successive elements of the upsetting profile.

Moreover the backward movement of the anvil or abutment may be stopped during work and the anvil may be advanced by short distances, thus increasing the number of shapes obtainable by forging. In case the anvil stops and above all in case it advances during work, the other electrode guiding the bar has to be displaced at the same time in a direction opposite to that in which the bar advances in order not to decrease, or rather to increase the distance between the electrodes during this period of the process.

This invention relates further to:

Means for adjusting the movement of the electrodes and the advancement of the bar as well as the heating current.

A device adapted to displace during the upsetting process the anvil head in a plane normal to the bar axis in order to obtain excentric or inclined or curved forged pieces.

A system of ball bearings provided in the vise forming the electrode guiding the bar, wherein the balls are arranged in such manner as to fit any form and size of the bar under treatment within wide limits ensuring a good contact without any abnormal heating for the flow of the necessary current intensity; said balls producing, when rolling, a rolling friction, which, as is well known, is much smaller than the sliding friction generated in the bearings of the machines known heretofore and the variations whereof according to the conditions of the surfaces, are much smaller so that during work the pressure with which the bar is pressed against the anvil can be maintained reliably constant and equal to that previously determined in consideration of the feature of the metal and size of the piece for a good forging result. This system of guide electrode with roller bearings gives further the important advantage that it is possible to treat bars even if not drawn, which was impossible with the smooth bearings with sliding friction known heretofore;

An anvil or abutment forming the other electrode detachably mounted on the rod feeding the current, made of a material having an ohmic resistance about equal to that of the bar under treatment and a larger diameter than the bar but such that it permits a lower temperature to be reached than that of the bar end, said temperature being however high enough to avoid any objectionable cooling of the bar by conductivity; the anvil material having moreover a mechanical resistance to pressure high enough in order not to become permanently deformed under the pressure exerted on same by the bar end;

An induction regulator inserted in the primary circuit of the transformer so as to maintain the potential almost constant during the whole of the forging process;

A transformer group adapted to deliver the necessary current for heating the piece during forging, comprising a main transformer the primary circuit whereof is divided into a series of sections variable in number inserted in the circuit by means of a load changing device and an auxiliary auto-transformer shunt on the primary circuit of the main transformer and subdivided also into sections that can be inserted into the circuit by means of a suitable commutator. This auto-transformer is adapted to increase the regulating range of the heating current so as to control the heating action exactly according to the size of the work piece;

A special system of working the machine and operating the electrode serving as anvil, the guide electrode and the forward motion of the bar.

The acompanying drawings show diagrammatically and by way of example a constructional form of the machine forming the object of this invention and some details of same.

Figures 1 and 2 show diagrammatically the upsetting system known heretofore according to which the electrodes are held stationary during work; Figure 1 shows the bar in the position in which the upsetting operation begins; Figure 2 shows the maximum upsetting obtainable.

Figures 3 to 6 show diagrammatically the upsetting appliance having electrodes moving during work according to the principle forming the object of this invention; in Fig. 3 the electrode serving as the anvil or abutment is held stationary while the other electrode is moved during work in a direction

opposite to that in which the bar advances. I thus obtain a bulb of upset material having the same shape as that obtainable through the known processes (Fig. 2) while completely eliminating the danger of burning the metal and making it possible to jolt a much larger mass of metal with equal features of the machine and bar section, it being further possible to treat big pieces.

In Fig. 4 the anvil or abutment has been displaced during work at a uniform speed thus upsetting to a cylindrical shape. In Fig. 5 the anvil is made movable at successive constant and increasing speeds, whereby a forged piece is obtained consisting of a plurality of cylinders having decreasing diameters suitably connected together. Figure 6 shows one of the many other forms of carrying out the forging process, this piece consisting of two spherical parts connected by a cylindrical portion and being obtained by holding the electrode working as anvil stationary through a short period in order to form the first sphere, then displacing it at a constant speed in order to form the cylindrical portion and holding it stationary again in order to form the second sphere.

In all these forms which permit upsetting of large metal masses I conveniently provide for the guide electrode to be moved in a direction opposite to that in which the bar advances, which becomes absolutely necessary when the anvil is stopped for considerable lengths of time during work as in the case of Fig. 6.

Figures 7 and 8 show a diagram of the appliances according to this invention with their respective operating means with movable anvil and movable guide electrode, respectively, for removing the electrodes from each other during the upsetting process. Figure 7 diagrammatically shows the transformer group employed according to the invention.

Fig. 8[a] shows a diagram of the appliances according to this invention wherein both the anvil or abutment and the clamping or guide electrode are arranged for movement.

Figures 9 and 10 show in front elevation a plan view respectively a machine for forging and roughening out iron and steel bars to pieces of any form even of large size.

Fig. 11 is a sectional view of a device adapted to adjust the motion of the electrode serving as anvil during the forging process and Figure 11[a] is a detail view of a cam of said device.

Figures 12 and 13 show in cross section and axial longitudinal section respectively a diagrammatical constructional form of the ball bearings of the vise of the electrode guiding the bar.

Figure 14 is a sectional view of the anvil against which the end of the bar under treatment is pushed.

As shown in Figures 1 and 2, according to the known machines wherein the distance between the electrodes 2 and 4 is not varied during work, the segment A of the bar 1 with a constant section equal to the initial section of the bar held between the electrodes gradually decreases from its maximum value determined by the distance between the electrodes (Fig. 1 at the moment in which work begins) down to a few millimeters (Fig. 2) at the end of the forging operation.

This very small portion to which the bar segment held between the electrodes is reduced towards the end of the work (Fig. 2), being in nearest proximity to the electrode 4 strongely cooled in which the bar is subjected owing to a well known phenomenon to a rise in temperature which is added up to the already much higher temperature than the initial one due to the Joule effect which inevitably brings about an alteration of the material, and affects, more especially in the case of steel, the zone connecting this segment to the upset portion, and in certain cases produces burning of the material or even melting of same in said zone and detachment of the jolted portion if the operation is carried on to the obtainment of the maximum upsetting volumes determined by the distance between the electrodes.

In the known machines it is not possible to obviate these disadvantages by moving the electrodes further apart, as this would bring about amongst other inconveniences the serious drawback that the bar portion A comprised between the electrodes would be too long with respect to its section in consideration of the load applied thereto for jolting, so that the bar when being upset would bend laterally under the action of the end load and the piece would be deformed and therefore faulty.

Moreover by the known means the upset piece can only show the approximative shape of an ellipsoid of revolution shown in the drawing, big pieces cannot be treated nor can large volumes of metal with respect to the bar size be upset.

According to this invention the distance between the electrodes is increased during the upsetting operation, so that there is always between the electrodes until the end of the upsetting operation a bar portion having a constant section equal to the initial bar section, about the same length as the original bar portion and in any case such that it prevents the rapid rise of the current intensity thus obviating the above mentioned disadvantages so that the work can be prolonged during all the time required for forging large pieces and upsetting large volumes of metal without risk of the temperature exceeding the limits required for a good forging result.

The gradual increase of the distance between the electrodes during work absolutely

avoids any lateral bending at the beginning of the forging operation while allowing large volumes of metal to be upset with respect to the bar size.

The displacement taking place during work of the electrode working as the anvil or abutment at a speed variable at will and with any desired stopping points makes it possible to obtain any profile of the forged piece as shown by way of example in Figures 4, 5 and 6.

In Fig. 3 the anvil 2 is assumed to be stationary while the guide electrode 4 is displaced during work in a direction contrary to that in which the bar 1 advances. In this case the forged piece takes the only form obtainable by the machines known heretofore, i. e. a shape similar to an ellipsoid of revolution with the advantage however of avoiding the sharp connection with the bar while it is possible, as stated above, to hold until the end of the operation a considerable bar portion having a constant section equal to the initial bar section between the electrodes, thus avoiding any rise of temperature above the limit required for a good forging result even if the work lasts some minutes longer, allowing at the same time larger volumes of metal of being upset.

In the constructional form diagrammatically shown in Fig. 7, only the anvil is made movable and a hydraulic operating mechanism has been provided.

A ram 8 on the rod whereof rests the anvil 2 is mounted in a cylinder 9 connected with a hydraulic accumulator (not shown for the sake of simplicity) through a valve or cock 10. The valve 10 can be opened e. g. by a cam 14 carried by a rod 11 fast with the member 3 pushing the bar 1 and acted upon by the ram 5 of the hydraulic cylinder 6.

The pressure upon the piston 8 shall of course be smaller than that exerted on the ram 5. The cam 14 is slidable on the rod 11 so as to adjust exactly the moment at which the cock or valve 10 shall be closed allowing thereby displacement of the piston 8 and anvil 2. Means are provided for adjusting the height of the cam and therefore the degree of aperture of the valve or cock 10 in order to regulate the speed of the anvil 2.

When work begins the anvil or abutment is stationary as the cock 10 is closed and the piston 8 cannot move within its cylinder. As soon as the cock 10 opens (this happening at the beginning of the upsetting operation) the electrodes 2 and 4 begin to move from each other. At the end of the upsetting treatment after the heating current has been cut off, the cylinder 6 transmitting the pressure is discharged through the cock 7 thus pushing back quickly the upset bar and the piston 8 is returned to its initial working position ready for a fresh upsetting treatment.

Figure 8 referring to a modified form shows diagrammatically an operating mechanism for automatically displacing the vise 4 in order to move this latter apart from the other electrode during jolting. To this purpose the vise 4 is provided with a rack 9' meshing with a differential pinion 10' turning on a fixed pivot and meshing on the side opposite to its pivot and by its other set of teeth with another rack 14' slidably mounted on the rod 11 connected to the push rod 3.

The transformer group according to this invention is shown in Fig. 7.

The group comprises a main transformer 15, the primary winding of which is divided into a plurality of sections variable in number inserted in the circuit by means of the load varying device 16 and an auxiliary auto-transformer 17 shunt on the primary winding of the main transformer and also subdivided in a number of sections that can be put in the circuit by means of a commutator 18. It is clear that the auto-transformer has been adopted in order to obtain a wider regulating range of the heating current in order to regulate exactly the heating action according to the size of the work piece.

Referring to Figures 9, 10 and 11 showing a general constructional form of the machine: 21 denotes the machine frame enclosing the electric transformer and regulating and operating appliances 22 denotes the main transformer, 23 the automatic cut-out at the stroke end, 24 the switch of the auto-transformer, 25 the operating mechanism for the switch of the transformer plugs, 26 the hand wheel operating the induction regulator 27, 28 the auto-transformer and 29 the transformer for automatically cutting off the current at the end of the stroke.

On the end of the machine bed are mounted the hydraulic cylinder 6 by which the bar is pushed and cylinder 9 for moving the electrode 2 serving as the anvil or abutment. Within the cylinder 6 slides the ram 5 transmitting pressure to the bar 1 through the push rod 3; within the cylinder 9 slides the ram 8, the rod 8' whereof conveniently guided abuts against the anvil 2 forming the electrode against which the work bar 1 is pushed. 4 denotes the other electrode guiding the bar and shown on the drawing as being fixed to the bed for simplicity's sake, while it is actually movable in a direction opposite to that in which the bar advances e. g. through mechanical means shown in Fig. 7 and Fig. 8a. 30 and 31 denote two hydraulic accumulators, capable of maintaining a constant pressure during work, the former having a higher pressure than the latter, and said pressure being liable to increase or decrease (according to the section of the work piece and the features of the metal of which the piece is made) by operating a suitable pump not shown. The accumulator 31 works with a closed cycle as described hereinafter and its pressure can be

raised by opening the cock 32 interposed on the conduit 33 connecting both accumulators. 34 denotes the operating mechanism of the machine which can establish communication between the conduit 35 branched from the accumulator 30 and the conduit 36 opening into the outer end of the cylinder 6 thus bringing the pressure on the piston 5 that transmits same through the push rod 3 on to the bar 1 pressing same against the anvil 2. This pressure that is kept constant during operation shall, according to this invention, be equal to the unitary pressure capable of permanently deforming the material of which the bar is made at the best temperature for obtaining a good forging result on said material multiplied by the bar section. It is thus possible to commence forging as soon as the bar has reached the temperature previously determined as best suited to the purpose, said temperature being maintained until the end of the operation by the effect of the gradual drawing apart of the electrodes during working.

From the lower pressure accumulator 31 is branched a conduit 37 opening into the lower end of a vertical cylinder 38, in which a piston is slidable, the rod whereof is connected to a swing lever 39 acting upon the vise 4 of the electrode guiding the bar. The accumulator 31 thereby holds the vise 4 automatically closed with a constant pressure.

Into the upper end of the cylinder 38 opens a conduit 40 that is connected through the operating mechanism 34 with the conduit 35 and therefore with the higher pressure accumulator 30 thus opening the vise at the end of the work when the operating mechanism 34 connects the conduit 36 with the relief pipe 41 thus relieving pressure from the bar. The quick return of the push rod 3 is produced by the fact that a branch pipe 37′ of the conduit 37 constantly communicates with the end of the cylinder 6 opposite to that receiving the conduit 36 thus establishing a counter-pressure on the ram 5.

When determining the working pressure of the accumulator 30 necessary for obtaining the desired pressure of the bar 1 against the anvil, this counter-pressure constantly exerted upon the ram 5 by the accumulator has of course to be considered.

The cylinder 9 is filled with oil or other suitable liquid which also fills completely the tubes 42 connecting the outer end of said cylinder 9 with the end of another cylinder 43, in which is mounted the piston 44 and the other end whereof freely communicates with a branch pipe from the conduit 37 and therefore with the low pressure accumulator 31. In the conduit 42 is inserted the member operating the anvil 2, the section whereof is shown in the constructional form illustrated in Fig. 11. This member is acted upon by means of a hand wheel 45 and comprises a plurality of cams 46 keyed on shaft 47 of the hand wheel, each consisting of a plurality of projections adapted to operate through push rods 48 the successive openings of the valves 49. This arrangement is such that different positions of the hand wheel 45 cause one, two or more or all valves to open and as all the valves are inserted between the connecting pipes 50 and 51 of the apparatus with both tubes 42 branched from the cylinder 9 and from cylinder 43, respectively, it is possible, according as a smaller or larger number of valves open, to hinder more or less the flow of the oil from the cylinder 9 into the cylinder 43 and to obtain a higher or lower backward speed of the anvil 2. As the throttling ports situated in correspondance with each valve can be different from one another, a wider range of anvil speeds can be obtained by all possible combinations in the opening of the valves. As a constant pressure transmitted by the accumulator 31 is exerted upon the face of the piston 44 turned towards the conduit 37, the pressure transmitted to the anvil by the bar is also constant and a constant backward speed of the anvil corresponds to a given position of the adjusting mechanism 45.

This latter has further a closed position of the conduit 42 in which any movement of the anvil 2 is stopped. At the end of the work, the pressure transmitted by the bar against the anvil ceases and the pressure acting upon the piston 44 and generated by the accumulator 31 causes the oil to flow back into the cylinder 9 (and therefore the anvil to return to its initial position) through the maximum section of the liquid flow in the adjusting mechanism owing to the fact that all the valves open under the action of their respective springs. The adjusting member can be made as a cylinder always inserted in the conduit 42 and provided with slots having a section increasing from nought to a maximum, a piston sliding in said cylinder in order to vary the throttling action. The back flow of the oil would be effected through an automatic valve provided on said piston.

In order to upset excentric or inclined or curved pieces the machine is provided with an operating mechanism 56 for displacing the anvil 2 at will in a transversal direction.

Figures 12 and 13 show the bearings of the vise for the guide and contact of the bar with rolling friction. The bar is shown as of circular section but it is obvious that the same bearings can clamp bars having any other section e. g. hexagonal or other polygonal, oval or other section and a size varying within wide limits. 52 denotes the bearings carrying the balls 53 and fixed to the vise. The balls 53 of each bearing 52 are lodged in two longitudinal races 54 parallel to each other and to the bar axis and obtained in the bearing itself. The balls are

held in the bearings 52 by any known means e. g. by slightly upturning the edge of the bearings 52 that shall of course be situated beyond the plane passing through the center of the ball. Once the balls have been fitted in, the races 54 are closed by means of end plates 55.

It is clear that one race 54 only for both ball rows can be obtained in each bearing 52 when the size of the balls is such that they can be brought together until they contact. The balls 53 are fitted with a certain play into the race 54 in order to allow them of rotating freely and pressing all the balls for a good contact on the bar 1 under the clamping pressure of the vise.

It is clear that whatever be the size or shape of the bar 1 the vise bearings always fit the bar automatically establishing a good contact on all the balls.

When the axial pressure is brought to act upon the bar 1 in order to effect upsetting, the bar advances towards the anvil or abutment and the balls 53 roll upon the bar maintaining a good contact continuously renewed owing to the rolling of the balls which, as experience has shown, allow the necessary current intensity to flow through without any considerable heating of the contact points and with a rolling friction without bringing about any sliding effect.

With the bearings according to this invention it is possible to heat treat bars even if not drawn and a great economy is realized with respect to the systems employing smooth sliding bearings with sliding friction as in the prior machines which had to be fitted with a very large and expensive number of bearings suiting all sizes and forms of the bars and requiring frequent repairs and changes owing to the scratches frequently caused on their inner surfaces by small chips, burs or foreign matter on the drawn bars. The bearings with sliding friction show another disadvantage i. e. quite small differences in the bar diameter that are to be found even on drawn bars affected the contacts enormously, burning the work piece laterally. All such drawbacks are fully removed by the bearing according to this invention.

Figure 14 shows the improved electrode working as anvil.

The head of the anvil 2 is simply fitted upon the rod 8′ receiving the electric current, and is made of a material having about the same ohmic resistance as the material of which the bar 1 is made that is pressed against the anvil for upsetting and has a larger diameter than the bar 1, such diameter being such that its temperature owing to the flow of the electric current reaches a value lower than that of the temperature of the bar 1 but still high enough (e. g. one half of that reached by the end of the bar itself). In this case the objectionable heat subtraction at the bar end during forging that takes place in the known machines is done away with.

The material of which the anvil is made shall obviously have a sufficient mechanical resistance in order to prevent its permanent deformation during the pressure exerted thereon by the bar end during upsetting.

Claims:

1. The method of forging metallic stock which consists in including the portion of the stock to be worked in an electric circuit and between two electrodes, heating the stock electrically to forging temperature, applying sufficient longitudinal pressure to the stock in the direction of one of the electrodes to change the profile of the stock, and increasing the distance between the electrodes during the forging treatment.

2. The method of forging metallic stock which consists in including the portion of the stock to be worked in an electric circuit and between two electrodes, heating the stock electrically to forging temperature, applying longitudinal pressure to the stock in the direction of its length, increasing the distance between the electrodes at a rate to maintain portions of the stock between the electrodes substantially equal to the stock length and cross-section initially positioned until the termination of the treatment.

3. The method of forging metallic stock to predetermined shapes which consist in positioning the stock between two electrodes, heating the stock electrically to forging temperature, applying sufficient longitudinal pressure to the stock in the direction of one of the electrodes to change the profile of the stock, and controlling the shape of the stock being forged by increasing the distance between the electrodes during the forging operation in accordance with the shape desired.

4. The method of forging metallic stock which consists in including the portion of the stock to be worked in an electric circuit and between two electrodes, heating the stock electrically to forging temperature, applying sufficient longitudinal pressure to the stock and in the direction of one of the electrodes to change the profile of the stock, and moving each of said electrodes away from the other during the forging treatment.

5. The method of forging metallic stock which consists in including the portion of the stock to be worked in an electric circuit and between two electrodes, heating the stock electrically to forging temperature, applying sufficient longitudinal pressure to the stock in the direction of one of the electrodes to change the profile of the stock, and moving one of said electrodes away from the other during the forging treatment.

6. The method of forging metallic stock

which consists in including the portion of the stock to be worked in an electric circuit and between two electrodes, heating the stock electrically to forging temperature, applying sufficient longitudinal pressure to the stock in the direction of one of the electrodes to change the profile of the stock, and moving the electrode serving as the abutment away from the other electrode.

7. The method of forging metallic stock which consists in including the portion of the stock to be worked in an electric circuit between two electrodes, one serving as an abutment and the other as a guide, heating the stock electrically to forging temperature, applying sufficient longitudinal pressure to the stock in the direction of the abutment electrode to change the profile of the stock and moving the abutment electrode away from the guide electrode during the forging treatment.

8. The method of forging metallic stock which consists in including the portion of the stock to be worked in an electric circuit between two electrodes, one serving as an abutment and the other as a guide, heating the stock electrically to forging temperature, applying sufficient longitudinal pressure to the stock in the direction of the abutment electrode to change the profile of the stock and moving the abutment electrode in the same direction as that of the stock pressure during the forging treatment.

9. The method of forging metallic stock which consists in including the portion of the stock to be worked in an electric circuit between two electrodes, one serving as an abutment and the other as a guide, heating the stock electrically to forging temperature, applying sufficient longitudinal pressure to the stock in the direction of the abutment electrode to change the profile of the stock and moving the abutment electrode away from the guide electrode, maintaining the latter stationary meanwhile, during the forging treatment.

10. The method of forging metallic stock which consists in including the portion of the stock to be worked in an electric circuit between two electrodes, one serving as an abutment and the other as a guide, heating the stock electrically to forging temperature, applying sufficient longitudinal pressure to the stock in the direction of the abutment electrode to change the profile of the stock, moving the abutment electrode in a direction opposite to that of bar advance, and moving the guide electrode in the same direction of travel as the abutment at a higher speed during the forging treatment.

11. In apparatus for electrically forging metallic stock, the combination of a guiding electrode having sliding contact with the stock, an electrode serving as an abutment for one end of said stock, means for advancing said stock in the direction of the abutment, and means synchronized with the movement of the stock advancing means for increasing the distance between the electrodes during the forging operation.

12. In apparatus for electrically forging stock, the combination of a guiding electrode having sliding contact with the stock, an electrode serving as an abutment for one end of said stock, means for advancing said stock in the direction of the abutment, and means synchronized with the movement of the stock advancing means for moving said guiding electrode and abutment away from each other during the forging operation.

13. In apparatus for electrically forging stock, the combination of a guiding electrode having sliding contact with the stock, an electrode serving as an abutment for one end of said stock, means for advancing said stock in the direction of the abutment, and means synchronized with the movement of the stock advancing means for moving the abutment in the direction of stock advance during the forging operation.

14. In apparatus for electrically forging stock, the combination of a guiding electrode having sliding contact with the stock, an electrode serving as an abutment for one end of said stock. means for advancing said stock in the direction of the abutment, means synchronized with the movement of the stock advancing means for moving the abutment in the direction of stock advance during the forging treatment, and means for subsequently restoring the abutment to original position.

15. In apparatus for electrically forging stock, the combination of a guiding electrode having sliding contact with the stock, an electrode serving as an abutment for one end of said stock, means for advancing said stock in the direction of the abutment, means synchronized with the movement of the stock advancing means for moving the abutment in the direction of the stock advance during the forging operation, and means for subsequently restoring the bar advancing means to original position.

16. In an apparatus for electrically forging a metal bar, the combination with a clamping electrode for sliding contact with said bar, an electrode serving as an abutment to engage one end of said bar and means for feeding said bar towards the abutment, of means for displacing the abutment in the direction of length of the bar and means for displacing the clamping electrode in a direction opposite to that in which the bar advances during forging.

17. In an apparatus for electrically forging a metal bar, the combination with a clamping electrode having sliding contact with said bar and an electrode serving as an abutment to engage one end of said bar, of

means for displacing the abutment during the forging operation and means for varying the speed of the abutment displacement during forging.

18. In apparatus for electrically forging metallic stock, the combination with a clamping electrode having sliding contact with said stock and an electrode serving as an abutment to engage one end of said stock, of means for displacing the abutment during the forging operation, and means for varying the time of beginning of abutment displacement.

19. In apparatus for electrically forging metallic stock, the combination with a clamping electrode having sliding contact with said stock, and an electrode serving as an abutment to engage one end of said stock, of means for displacing the abutment during the forging operation, and means for varying the amplitude of abutment displacement.

20. In an apparatus for electrically forging a metal bar, the combination with a clamping electrode for sliding contact with said bar, an electrode serving as an abutment to engage one end of said bar and means for feeding said bar towards the abutment, of means for displacing the abutment in the direction of length of the bar, means for displacing the clamping electrode in a direction opposite to that in which the bar advances during operation, and means for adjusting the speed of displacement of one of said electrodes to keep between said electrodes until the end of the forging process a predetermined bar length having a constant cross section equal to the initial bar section.

21. In an apparatus for electrically forging a metal bar, the combination with a clamping electrode for sliding contact with said bar, an electrode serving as an abutment to engage one end of said bar and means for feeding said bar towards the abutment, of means for maintaining during forging a constant bar pressure against the abutment corresponding to the unitary pressure required for producing the permanent deformation of the material at the temperature best suited for obtaining good forging results multipled by the bar section and of means for varying the distance between the electrodes during forging.

22. In an apparatus for electrically forging a metal bar, the combination with a clamping electrode for sliding contact with said bar, an electrode serving as an abutment to engage one end of said bar and means for feeding said bar towards the abutment, of means for maintaining during forging a constant bar pressure against the abutment corresponding to the unitary pressure required for producing the permanent deformation of the material at the temperature best suited for obtaining good forging results multiplied by the bar section, and of means for increasing the distance between the electrodes during the operation.

23. In an apparatus for electrically forging a metal bar, the combination with a clamping electrode for sliding contact with said bar, an electrode serving as an abutment to engage one end of said bar and means for feeding said bar towards the abutment, of means for maintaining during operation a constant bar pressure against the abutment corresponding to the unitary pressure required for producing the permanent deformation of the material at the temperature best suited for obtaining good forging results multiplied by the bar section, and means for displacing the abutment during work, in the same direction in which the bar advances.

24. In an apparatus for electrically forging a metal bar, the combination with a clamping electrode for sliding contact with said bar, an electrode serving as an abutment to engage one end of said bar and means for feeding said bar towards the abutment, of means for maintaining during operation a constant bar pressure against the abutment corresponding to the unitary pressure required for producing the permanent deformation of the material at the temperature best suited for obtaining good forging results multiplied by the bar section, means for displacing the abutment in the direction in which the bar advances during work, and means for adjusting the speed of the abutment displacement.

25. In an apparatus for electrically forging a metal bar, the combination with a clamping electrode for sliding contact with said bar, an electrode serving as an abutment adapted to engage one end of said bar and means for feeding said bar towards the abutment, of means for maintaining during operations a constant bar pressure against the abutment corresponding to the unitary pressure required for producing the permanent deformation of the material at the temperature best suited for obtaining good forging results multiplied by the bar section, means for displacing the abutment in the direction of length of the bar and means for displacing the clamping electrode in a direction opposite to that in which the bar advances during the operation.

26. In an apparatus for electrically forging a metal bar, the combination with a clamping electrode for sliding contact with said bar and an electrode serving as an anvil to engage one end of said bar and means for feeding said bar towards the abutment, of a hydraulic cylinder, means movable in said cylinder and connected with said abutment for moving said abutment in the direction of length of the bar, a constant pressure hydraulic accumulator, a conduit connecting

said accumulator with said cylinder and a valve adjusting device in said conduit.

27. In an apparatus for electrically forging a metal bar, the combination with a clamping electrode for sliding contact with said bar, an electrode serving as an abutment to engage one end of said bar and means for feeding said bar towards the abutment, of a hydraulic cylinder, means movable in said cylinder and connected with said abutment for moving said abutment in the direction of length of the bar, a constant pressure hydraulic accumulator, a conduit connecting said accumulator with said cylinder and a valve-governing device in said conduit, said hydraulic accumulator being such that the pressure it exerts on the plunger, when the valve governing device is open, is less than the pressure transmitted by the bar to the abutment, so that the variations of the abutment speed are obtained during operation by varying the degree of aperture of the valve-governing device.

28. In an apparatus for electrically forging a metal bar, the combination with a clamping electrode for sliding contact with said bar, an electrode serving as an abutment to engage one end of said bar and means for feeding said bar towards the abutment, of a hydraulic cylinder, means movable in said cylinder and connected with said abutment for moving said abutment in the direction of length of the bar, a constant pressure hydraulic accumulator, a conduit connecting said accumulator with said cylinder, a valve-governing device in said conduit and means for displacing during operation the clamping electrode in a direction opposite to that in which the bar advances.

29. In an apparatus for electrically forging a metal bar, the combination with a clamping electrode for sliding contact with said bar, an electrode serving as an abutment to engage one end of said bar and means for feeding said bar towards the abutment, of a hydraulic cylinder, means movable in said cylinder and connected with said abutment for moving said abutment in the direction of length of the bar, a constant pressure hydraulic accumulator, a conduit connecting said accumulator with said cylinder, a valve governing device in said conduit and means for displacing during operation the clamping electrode in a direction opposite to that in which the bar advances, said means being operated by the means feeding the bar towards the abutment.

30. In an apparatus for electrically shaping a metal bar, the combination with an abutment electrode for engaging one end of said bar and means for feeding said bar towards said abutment of a hydraulic cylinder, a plunger movable in said cylinder and connected with said abutment for moving said abutment in the direction of length of the bar, a second hydraulic cylinder having a volume equal to that of the first-named cylinder, a free plunger in said second cylinder, a conduit connecting the first-mentioned cylinder with one end of the second cylinder, the space between said plungers the cylinders and the conduit interconnecting them being filled with liquid, an adjusting member inserted in said conduit for adjusting the liquid flow from one cylinder to the other, a constant pressure accumulator, and a conduit connecting the other end of the second cylinder constantly with the accumulator.

31. In an apparatus for electrically shaping a metal bar, the combination with a clamping electrode for sliding contact with said bar, an electrode serving as an abutment to engage one end of said bar and means for feeding said bar towards the abutment, of a hydraulic cylinder, a plunger movable in said cylinder and connected with said abutment for moving said abutment in the direction of length of the bar, a second hydraulic cylinder having a volume equal to that of the first-named cylinder, a free plunger in said second cylinder, a conduit connecting the first-mentioned cylinder with one end of the second cylinder, the space limited between said plungers, the cylinders and the conduit connecting them being filled with liquid, a member for adjusting the liquid flow from one cylinder to the other inserted in said conduit and comprising a body having a plurality of ports communicating with said conduit and having different cross-sections, valves cooperating with each of said ports, cams acting on said valves for successively closing said ports, a shaft carrying said cams and a handwheel for rotating said shaft, a constant pressure accumulator and a conduit connecting the other end of the second cylinder constantly with the accumulator.

32. In an apparatus as claimed in claim 30, a third hydraulic cylinder, a plunger movable in said cylinder and connected with the movable element of the clamping electrode, a conduit connecting one end of said cylinder with said accumulator for closing the clamping electrode, a second hydraulic accumulator having a higher pressure than the first-mentioned accumulator, a conduit connecting said second accumulator with the other end of the cylinder operating the clamping electrode for opening the latter, a fourth hydraulic cylinder to feed the bar, a conduit connecting the second accumulator with one end of said fourth cylinder for feeding the bar, another conduit connecting the other end of said fourth cylinder with the first mentioned accumulator having a lower pressure for returning the plunger of said third cylinder to its initial position when the action of the first-mentioned accumulator ceases.

33. In an apparatus as claimed in claim

30, a third hydraulic cylinder, a plunger movable in said cylinder and connected with the movable element of the clamping electrode, a conduit connecting one end of said cylinder with said accumulator for closing the clamping electrode, a second hydraulic accumulator having a higher pressure than the first-mentioned accumulator, a conduit connecting the second accumulator with the other end of the cylinder operating the clamping electrode for opening the latter, a fourth hydraulic cylinder operating to feed the bar, a conduit connecting the second acmulator with one end of said fourth cylinder for feeding the bar, another conduit connecting the other end of said fourth cylinder with the first-mentioned accumulator with a lower pressure for returning the plunger of said third cylinder to its initial position when the action of the first-mentioned accumulator ceases, and a valve actuating member inserted in the conduits between the third and fourth hydraulic cylinders and the first and second accumulator, said actuating member when transmitting the pressure of the hydraulic accumulator having a higher pressure to the cylinder pushing the bar forward disconnecting said accumulator from the clamping electrode, while when it is brought in position for discharging the cylinder pushing the bar forward at the end of the operation it automatically connects the accumulator at a higher pressure with the cylinder of the clamping electrode for opening the latter.

34. The method of forging metallic stock which consists in including the portion of the stock to be worked in an electric circuit and between two electrodes, heating the stock electrically to forging temperature, applying sufficient longitudinal pressure to the stock in the direction of one of the electrodes to change the profile of the stock and increasing the distance between the electrodes at a uniform speed during the forging treatment.

35. The method of forging metallic stock which consists in including the portion of the stock to be worked in an electric circuit and between two electrodes, heating the stock electrically to forging temperature, applying sufficient longitudinal pressure to the stock in the direction of one of the electrodes to change the profile of the stock, and moving one of said electrodes away from the other at a uniform speed during the forging treatment.

36. The method of forging metallic stock which consists in including the portion of the stock to be worked in an electric circuit and between two electrodes, one serving as an abutment and the other as a guide, heating the stock electrically to forging temperature, applying sufficient longitudinal pressure to the stock in the direction of one of the electrodes to change the profile of the stock and moving the abutment electrode in the same direction as that of the stock pressure at a uniform speed during the forging treatment.

37. The method of forging metallic stock which consists in including the portion of the stock to be worked in an electric circuit and between two electrodes, one serving as an abutment and the other as a guide, heating the stock electrically to forging temperature, applying sufficient longitudinal pressure to the stock in the direction of one of the electrodes to change the profile of the stock and moving the abutment electrode away from the guide electrode at a uniform speed during the forging treatment.

38. An electrode for a forging or welding machine comprising a casing provided with a stock receiving opening, a plurality of rotatable elements supported by said casing projecting inwardly from the walls of said opening and arranged axially and radially in respect to the axis of said opening, and a support for said casing.

39. An electrode for a forging or welding machine, comprising a plurality of relatively movable members constituting a separable casing having its inner surface arranged to provide a stock receiving opening, a plurality of rotatable elements projecting inwardly from said surface and supported thereby axially and radially in respect to the axis of said opening, a support for said casing, and means for opening and closing said members.

40. An electrode for a forging or welding machine comprising a housing composed of a plurality of spaced and relatively movable sections, said sections having opposing inner faces and providing an opening therebetween, a plurality of revoluble elements carried by each of said sections arranged axially and radially of the axis of said opening and projecting inwardly from the inner faces of said sections, and a support for said housing.

41. In an apparatus for electrically forging a metal bar, the combination with a clamping electrode for sliding contact with said bar, an electrode serving as an abutment to engage one end of said bar and means for feeding said bar toward the abutment, said abutment comprising a contact head made of a material having substantially the same ohmic resistance as that of the bar under treatment and a diameter larger than that of the bar.

In testimony that I claim the foregoing as my invention, I have signed my name.

EZIO GIACCHINO.