April 16, 1957 R. H. KILPATRICK ET AL 2,789,204

METHOD AND APPARATUS FOR HOT FORMING MATERIAL

Filed Sept. 30, 1954 3 Sheets-Sheet 1

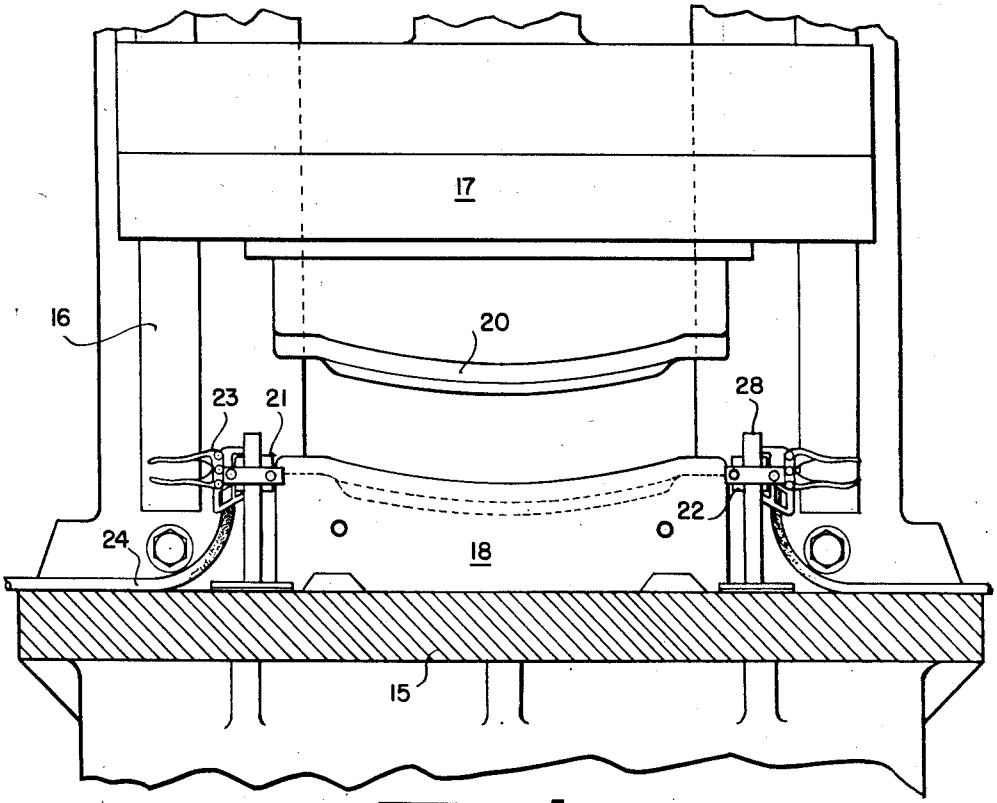


Fig. 1

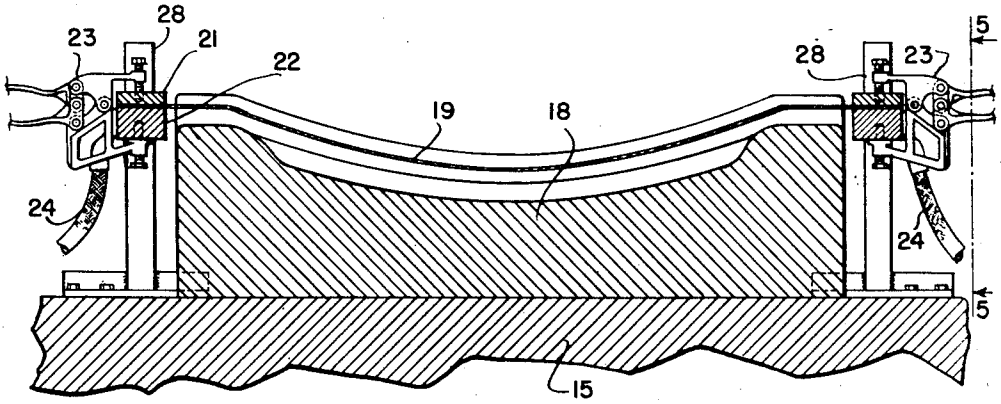


Fig. 2

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METHOD AND APPARATUS FOR HOT FORMING MATERIAL

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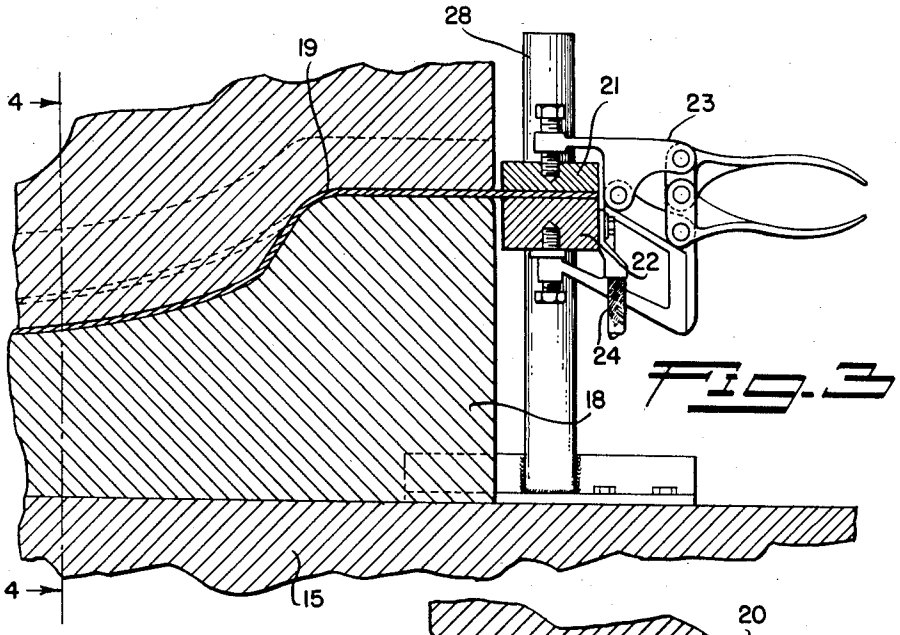


Fig. 3

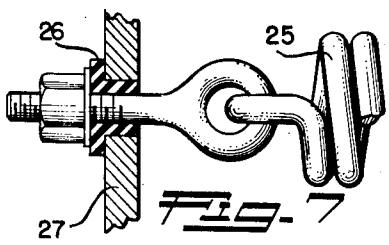


Fig. 7

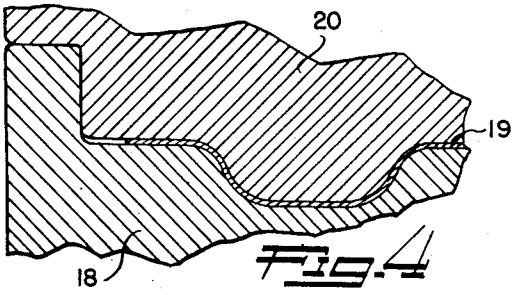


Fig. 4

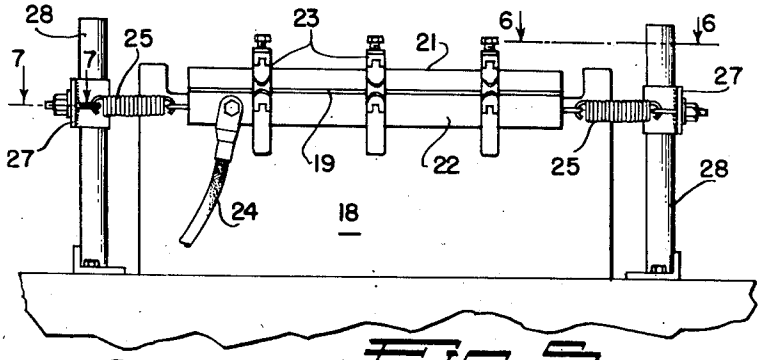


Fig. 5

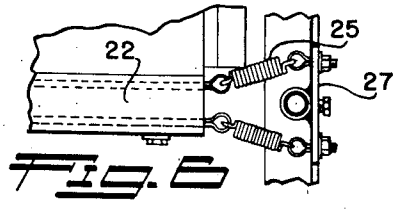


Fig. 6

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METHOD AND APPARATUS FOR HOT FORMING MATERIAL

Filed Sept. 30, 1954 3 Sheets-Sheet 3

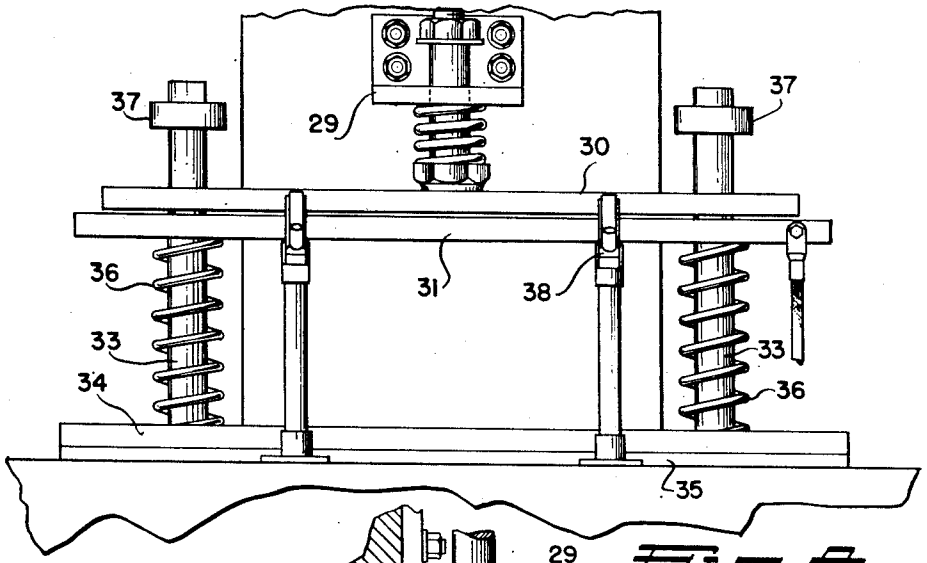


Fig. 8

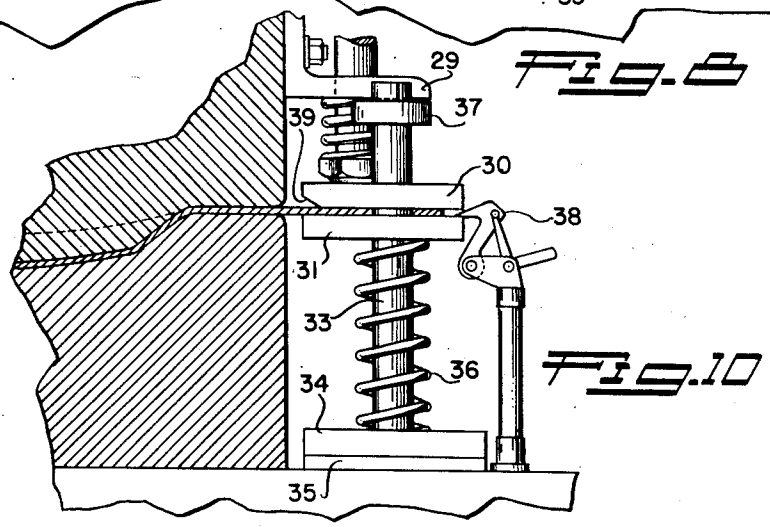


Fig. 10

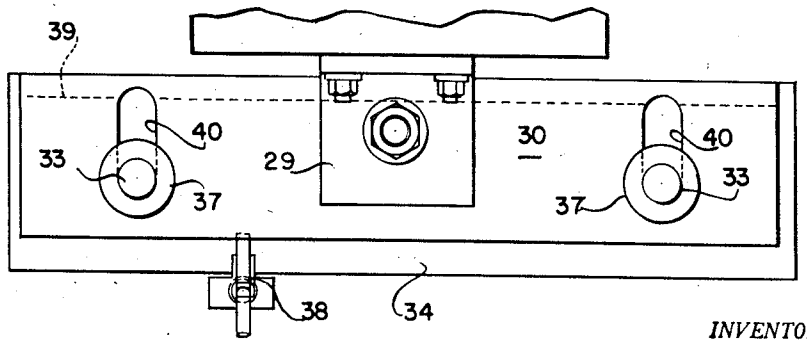


Fig. 9

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METHOD AND APPARATUS FOR HOT FORMING MATERIAL

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Application September 30, 1954, Serial No. 459,462

9 Claims. (Cl. 219—154)

This invention relates to a new method of hot forming material such as sheet aluminum, magnesium and titanium, in drop hammer, hydro press and punch press dies, wherein the material is heated prior to forming and then is formed to shape in the dies.

Because of the critical nature of such materials as aluminum, magnesium and titanium, forming these materials while heated facilitates the operation, prevents cracking, and substantially reduces spring back. Attempts have heretofore been made to heat the stock in ovens adjacent the press, but the transfer of heated blanks to the press involves uncontrollable cooling of the blanks and difficulty in handling the same, particularly when temperatures in excess of 500° are present. It has also been proposed to preheat the forming dies, a procedure limited by the material of the die and the problem of partly cooling the formed parts before removal thereof from the dies. The desired forming temperatures range from 350° F. for aluminum, 575° for magnesium and 850° to 1250° F. for titanium. It is an important object of our invention to suspend a suitable blank between the open dies of a press and to heat the blank in such a position, as by electric resistance means, so that as soon as the desired temperature of the blank is attained the dies are brought together to form the desired part.

It is a further object of this invention to suspend the blank between the open ram and die and to cause the descending ram to lower the blank into the die as the ram proceeds to form the heated blank into the desired shape.

It is another object of our invention to suspend a heated blank between open dies of a press so that no part of the heated blank will have contact with the cold dies until the forming blow, thereby preventing spot cooling of the blank prior to forming, and eliminating the use of insulating blankets.

A still further purpose of our invention is to utilize the unheated dies to quench the part as formed when desired and thus avoid spring-back or warpage of the formed part.

It is also an object of our invention to provide a method for continuously heating a blank between two dies before, during and after the forming blow where this is desired.

Another object of our invention is to provide a gripping or clamping means for suspending blanks between the open ram and die of a press in close proximity to but without permitting the blank to contact the unheated ram and die until the forming blow.

It is a further object of our invention to provide a guided and yielding gripping or clamping means for suspending such blanks between the open dies of a press with such suspension points being located outside the path of the descending die.

Other and further objects of this invention will appear from the following detailed description of an embodiment of the invention, as shown in the accompanying drawings wherein:

Figure 1 shows a vertical section through a drop hammer type of press with suitable punch and dies mounted

therein together with one form of mounting means for supporting and heating a sheet metal blank between the punch and die;

Figure 2 is a view similar to Figure 1 with the section taken through the punch and die;

Figure 3 is an enlarged detailed section of one end of Figure 2 showing the punch and die closed together with details of one of the blank supporting electrodes;

Figure 4 is a section taken on the line 4—4 of Figure 3 showing the cross section of a formed part;

Figure 5 is an end or side view of one of the blank supporting electrodes;

Figure 6 is a detailed top view taken on the line 6—6 of Figure 5;

Figure 7 is an enlarged detail of one of the supporting spring mountings for the electrode, taken on line 7—7 of Figure 5;

Figure 8 shows another form of blank supporting electrode forming an improved version of Figure 5;

Figure 9 is a top view of Figure 8; and

Figure 10 is a side or end view of Figure 8.

While the method of this invention can be performed in various types of drop hammer, hydro and punch presses, we have chosen to illustrate it as performed in a drop hammer type of press comprising a press bed **15** having vertical guides **16** for a ram **17**. Mounted on the bed **15** is a die **18** having a cavity shaped to form the desired part from a sheet blank **19**. A mating punch **20** is mounted on the ram **17** of the press, which ram may be lifted and dropped or forced down to bring the punch and die together. Such equipment is in common use where heating the material or blank is not involved, and in such cases the die member **18** is usually cast of Kirksite, a zinc alloy, or of cast resins developed for such purposes, as such materials can be salvaged for reuse when the particular die becomes obsolete or damaged. The punch **20** is usually cast in the formed die of a relatively hard lead alloy.

It has been found that such die and punch materials operate satisfactorily at room temperatures, but that attempts to heat such dies show the Kirksite dies will not stand temperatures above 500° so that attempts to reach higher working temperatures in the dies require the use of more expensive dies made of heat resistant materials, such as cast iron or steel. In addition, the heating of such dies to temperature substantially above 550° to 600° F. is impractical.

Our invention, therefore, relates to the heating of the blank while suspended in position between the punch and die, so that cooling losses are avoided by the ability to strike the blank quickly after the blank optimum forming temperature has been reached. As a corrolary, the punch and die can be used to die quench the blank after forming as the massive dies can absorb the heat from the material of the part without reaching critical temperatures for the die material. Suspending the blank in position during the heating thereof not only eliminates cooling losses during the transfer of the blank but eliminates the need of insulation between the blank and die when heating the blank by electric resistances. To so heat the blank, the suspension arrangement incorporates electrodes from a suitable source of heating current such as a portable arc welder unit or suitable transformer. Depending on the cross-sectional area of the blank, we have found that a 75 kva. spot welder transformer will supply adequate amperage at low voltage to heat the blank within periods ranging from a few seconds to a minute or two, the circuit normally being broken when the blank reaches the desired temperature. Immediate operation of the press eliminates air cooling of the blank, and if desired automatic temperature control may operate the press and the heating circuit may be broken by

the descent of the punch or press ram, to further reduce the cooling time of the blank.

Suspension of the blank renders it unnecessary to interpose insulation between the blank and the die. If desired the blank may be preformed to the approximate curve of the die to delay initial contact of the punch therewith until the blank is in a position to be formed by the punch.

The suspension arrangements for the blank as shown in Figures 1 to 6 comprise electrode bars **21** and **22** clamped against the ends of the blank, as by toggle clamps **23**. A lead-in wire **24** from a source of low voltage high amperage electricity, such as a transformer or portable arc or spot welding generator (not shown) is attached to the lower bar **22** and completes a circuit through the blank connecting the two electrodes. Each end of the lower bar **22** is supported by springs **25** having insulated connections **26** to a cross beam **27** supported by posts **28** mounted on the bed of the press clear of the die, so that the blank is yieldingly supported above the die impression yet can be pushed down into the die impression by the descending punch.

Alternatively the punch can carry depressors **29** directly contacting the electrodes to push them down, thus carrying the blank into the die without premature contact between the blank and punch, as shown in Figures 8 to 10 to be now described.

The second form of suspension disclosed comprises upper and lower electrode bars **30** and **31** apertured to move up and down on posts **33** extending from a base **34** resting on an insulated mounting **35** on the press bed. The bottom electrode bar is supported on springs **36** on the posts **33** which press upwardly to clamp the blank against the upper bar retained on the posts by collars **37**. With this arrangement the depressor **29** on the punch can press both bars down to lower the blank into the die, or can be arranged to press the lower bar down for the same purpose which would release the clamping pressure on the blank prior to the actual forming operation. After the blank is formed, latches or pawls **38** can be used to retain the lower bar in its depressed position to release the electrode pressure on the blank to facilitate removal of the formed blank after the punch is lifted. To facilitate placing the unformed blank in the electrodes the upper bars **30** may be beveled as at **39**, and the holes **40** in the bar elongated traversely to aid in inserting the ends of the blank between the electrodes.

In performing the improved method of this invention it is important to reduce the cooling of the heated blank by reducing the time between the attainment of the desired blank temperature and the operation of the press. Hot sheet metal will cool so rapidly after removal from a heating oven that the time involved in handling the same in placing it in the die will allow a substantial drop from the temperature attained, so that our method of resistance heating the blank while suspended between the punch and die gives superior results in that the time delay is practically eliminated so that overheating of the blank is not necessary in an attempt to allow for heat losses that would occur during the transfer of a hot blank. Further, where the optimum forming temperature is at or near the maximum allowed temperature and overheating cannot be tolerated, formability not obtainable by other methods may be obtained by our method. Our new and improved method of hot forming also eliminates manual handling of hot parts, enables the use of high currents in heating the blank without use of insulation between the blank and the die, permits immediate operation of the press when the heating current is cut, provides uniform heating of the blank, eliminates the need of heating ovens adjacent to the press, and does not require heating the dies to high temperature, such as by presently used means of embedded heating elements.

As an example, the magnesium blank 26" x 60" x .040" was heated to 520° F. in two minutes by using a 75 kva. transformer set at 5.2 volts. This blank was formed with one stroke of the press as compared with oven or die heated parts requiring several stages in the forming. As another example, a titanium blank 4" x 35" x .032" was clamped in the electrodes and suspended above the die. The blank was heated to 900° F. in 90 seconds by current of 450 amperes from a portable arc welding generator, and the blank hit by the punch within seconds after cutting the current. A second blow was not necessary and the part cooled to 660° F. in approximately 8 seconds after forming, illustrating the quenching action of the cool dies. Temperature readings were taken by potentiometer pyrometers.

While our invention has been described as used with a press operating a cooperating punch and die it is equally applicable to presses using only a die or form block, such as so-called stretch presses; where the blank can be mounted in the stretch jaws in spaced relation to the die and then heated in situ prior to stretching.

Having described only a typical process or method of heating and forming sheet material, we do not wish to be limited to the specific details herein set forth but wish to reserve to ourselves any variations or modifications that may appear to those skilled in the art and fall within the scope of the following claims.

We claim as our invention:

1. The method of hot forming metal blanks in a press of the type where a cold punch is used to force the blank into conformity with an impression in a cold die, comprising suspending the blank over the die impression by clamps engaging the blank beyond the confines of the punch, utilizing the clamps as electrodes for a resistance heating electrical circuit through said blank, heating said blank to a desired forming temperature and then opening the heating circuit and immediately energizing the punch to force the suspended blank into the impression in said die while the blank is being gripped by the clamps.

2. The method of hot forming sheet metal blanks in a press of the type where a cold punch is used to force the blank into conformity with an impression in a cold die, comprising yieldingly suspending the blank in close proximity to the die impression by clamping means engaging the blank beyond the confines of the punch, heating said blank to a desired forming temperature, and immediately energizing the punch to force the suspended blank into the impression in said die while the blank is being gripped by the clamping means.

3. The method of hot forming sheet metal blanks in a press of the type where a cold punch is used to force the blank into conformity with an impression in a cold die, comprising suspending the blank over the die impression by clamps engaging the blank beyond the confines of a punch, heating said blank to a desired forming temperature, immediately energizing the punch to force the suspended blank into the impression in said die while the blank is being gripped by the clamp, and then die quenching the formed blank in position between the closed punch and die.

4. The method of hot forming metal blanks in a press of the type where a cold punch is used to force the blank into conformity with an impression in a cold die, comprising yieldingly suspending the blank in close proximity to the die impression by clamps engaging the blank beyond the confines of the punch, utilizing the clamps as electrodes for a resistance heating electrical circuit through said blank, heating said blank to a desired forming temperature and then opening the heating circuit and immediately energizing the punch to force the suspended blank into the impression in said die.

5. In combination with a press including a punch and die for forming metal articles, means for suspending a suitable metal blank between the punch and die compris-

ing clamping bars for engaging opposite ends of the blank, said bars being in the form of electrodes, an electrical resistance heating circuit connected to said electrodes to complete the electrical circuit through the blank, means for yieldingly supporting said electrodes in insulated relationship to said press, punch and die whereby the gripping action of the clamping bars may be exerted on said blank throughout at least a portion of the forming operation, depresser means carried on said punch and arranged to engage said bars and effect movement of the blank towards the die in response to movement of the punch while maintaining the blank spaced from the punch, and means carried on the clamping bars for regulating the gripping force exerted on the blank.

6. In combination with a press including a separable punch and die set for forming metal articles, means for suspending a metal blank between the punch and die comprising a pair of bars disposed at opposite ends of the punch and die, each pair of bars engaging opposite sides of the blank, means for clamping the blank between the pairs of bars and electrically isolating the blank from the punch and die, electrical means converting said pairs of bars into electrodes for electrically heating said blank while in position between the punch and die, and means yieldingly supporting said pairs of bars whereby the gripping action of the bars is exerted on the blank throughout at least a portion of the forming operation, and depresser means carried on said punch and arranged to engage said bars and effect movement of the blank towards the die in response to movement of the punch while maintaining the blank spaced from the punch.

7. In combination with a press including a separable punch and die set for forming metal articles, means for suspending a metal blank between the punch and die comprising a pair of bars disposed at opposite ends of the punch and die, each pair of bars engaging opposite sides of the blank, means for clamping the blank between the pairs of bars, electrical means converting said pairs of bars into electrodes for electrically heating said blank while in position between the punch and die, mounting means for said bars comprising spaced guide posts on which the bars are carried, spring means normally urging said bars on said posts away from said die whereby the blank is suspended between the punch and die and electrically insulated therefrom, and depresser means carried on said punch and arranged to engage said bars and effect movement of the blank towards the die in response to movement of the punch while maintaining the blank spaced from the punch.

8. In combination with a press including a separable punch and die set for forming metal articles, means for suspending a metal blank between the punch and die comprising a pair of bars disposed at opposite ends of the punch and die, each pair of bars engaging opposite sides of the blank, means for clamping the blank between the pairs of bars, electrical means converting said pairs of bars into electrodes for electrically heating said blank only while in position between the punch and die and electrically insulated therefrom, yielding means for supporting said bars and the blank in suspended position between the punch and die whereby a gripping action may be exerted by the bars substantially throughout the forming operation, and latch means carried by the press for restraining the movement of at least one of the bars in each pair against the action of said yielding means.

9. In combination with a press including a separable punch and die set for forming metal articles, means for suspending a metal blank between the punch and die comprising a pair of bars disposed at opposite ends of the punch and die, a plurality of guide posts carried on the press and slidably receiving said bars, spring means for clamping the blank between the pairs of bars and exerting a gripping force thereon substantialy throughout the forming operations, stop means associated with said guide post for limiting the movement of said bars relative to the punch and die set whereby the blank may be suspended therebetween and electrically insulated from all but the bars, electrical means converting said pair of bars into electrodes for electrically heating said blank while in the suspended position between the punch and die, means carried by said punch for moving said bars to a retracted position relative to said guide posts against the action of said spring means in cooperation with the movement of the punch to position the blank in contact with the die for forming, and latch means arranged to engage the bars in the retracted position and release the clamping action of the spring means thereon.

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