

[54] **PROCESS AND APPARATUS FOR PERFORMING A SIMULTANEOUS AND COMBINED PRESS-FORMING AND HEAT-TREATMENT OF STEEL STOCK**

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[58] Field of Search72/342; 29/173; 148/12, 12.4, 148/130, 131; 266/2.5

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[57] **ABSTRACT**

The invention relates to a process for press-forming and heat-treating a metallic stock for the manufacture of a specifically shaped product having locally different hardness distributions in specifically selected patterns.

The forming and heating are performed in a simultaneous operation of the die press machine, whereby the stock is deprived of different amounts of heat at different temperatures in specifically localized zones.

4 Claims, 7 Drawing Figures

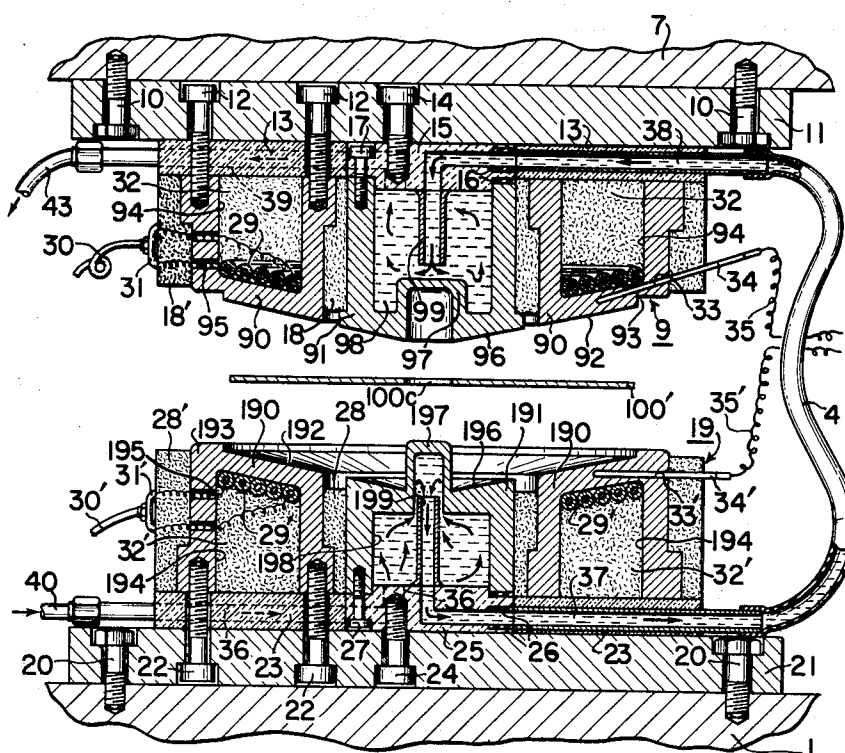


FIG. 3

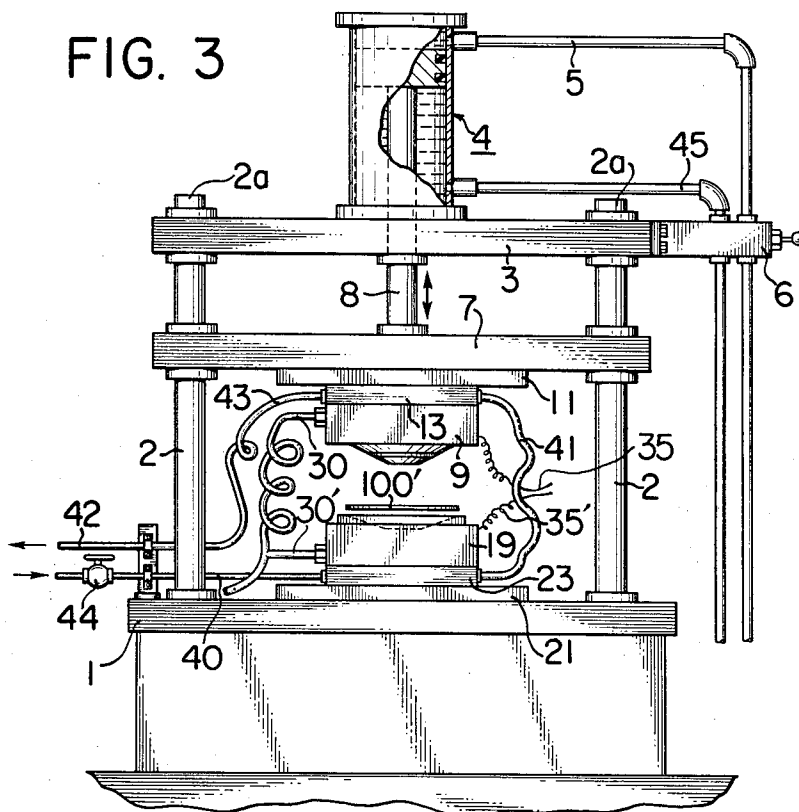


FIG. 1

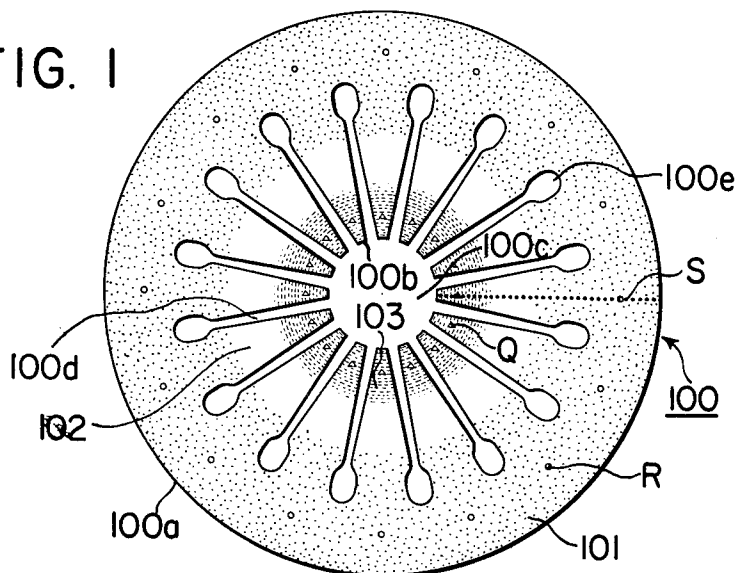
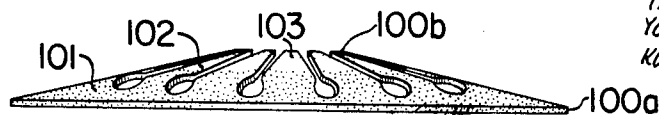


FIG. 2



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FIG. 4

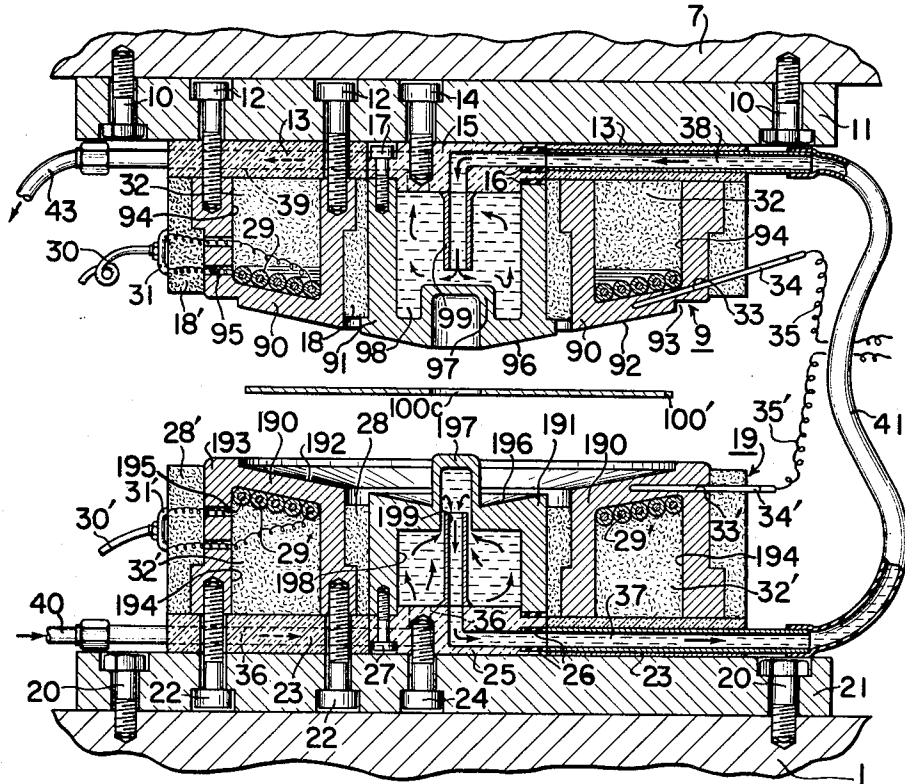


FIG. 5

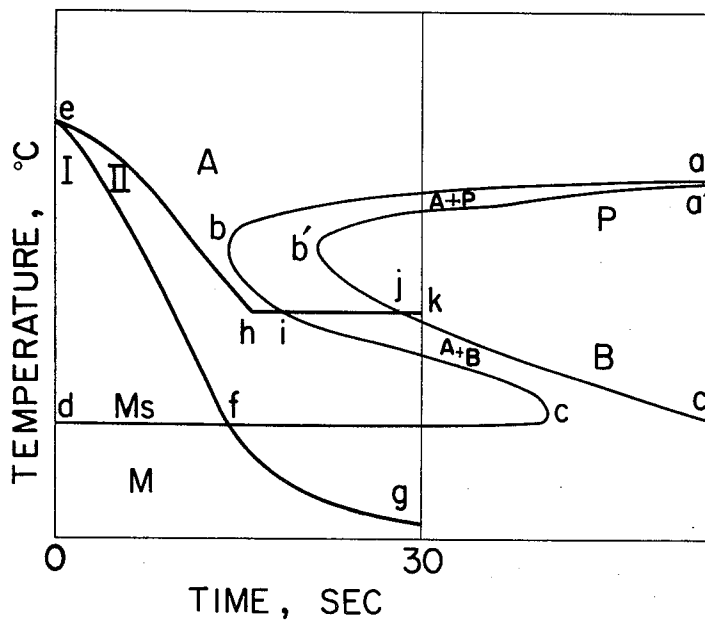


FIG. 6

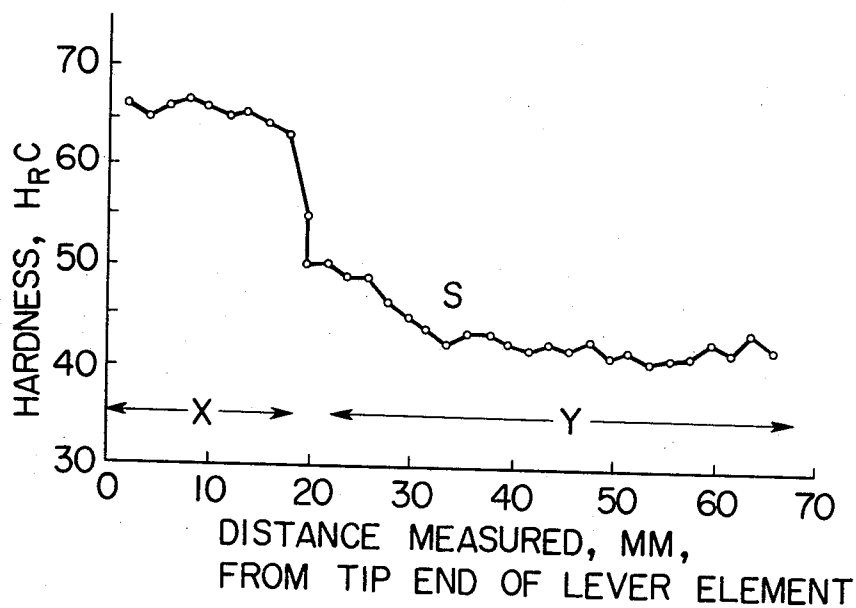
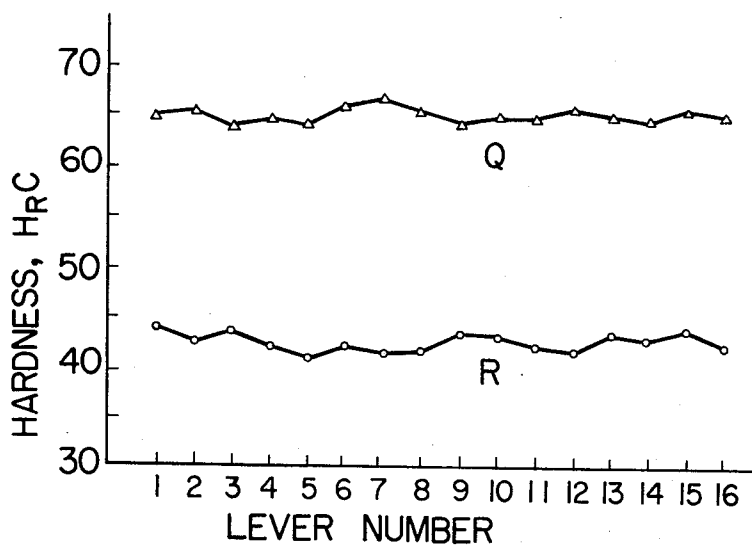


FIG. 7



PROCESS AND APPARATUS FOR PERFORMING A SIMULTANEOUS AND COMBINED PRESS- FORMING AND HEAT-TREATMENT OF STEEL STOCK

This invention relates to an improved process for simultaneously press-forming and heat-treating a metallic stock for the manufacture of a specifically shaped product having locally different hardness distribution of a specific pattern, and an apparatus for performing said process.

The "stock" to be processed according to this invention may preferably be steel sheet stock, having preferably a certain limited thickness range generally extending from 0.05mm to 20mm. The term "steel" as used hereinafter throughout the present specification may include steel alloys. Naturally, the stock may be a kind of semi-product prepared in a certain preceding process stage, independent of the process according to this invention.

It is a commonly employed conventional process for the manufacture of a product having a specifically press-formed physical shape and a locally different hardness distribution of a specifically selected pattern, for instance, such as a product having a first area of a quenched higher hardness and a second area of a tempered lower hardness, to mechanically press the stock into the desired shape and then to subject the thus press-formed stock to a heat treatment in a successive order. The heat treating job for this purpose may be classified generally into the following first and the second process.

In the first process, the stock as a whole is quenched, so as to provide a high hardness over its entire surface and to temper locally the quenched product, so as to represent a lower hardness over a specifically and intentionally selected local surface area of the stock.

In the second process, the stock as a whole is quenched and tempered, so as to represent a lower hardness over its entire surface, and then to re-quench locally the stock, so as to represent a higher hardness over a specifically selected local surface area of the stock.

In carrying out either of these known processes, it is absolutely necessary to perform the quench and the temper step separately from each other. It is naturally further necessary to remove quench distortions from the products by at least a separately performed additional step. As a whole, therefore, the whole heat treating steps are substantially complicated and tedious, as will become more apparent by later disclosures taking an examples of an automotive diaphragm spring.

Therefore, it will be clear from the foregoing that the conventional technique for the production of a product having a locally different hardness distribution of a specifically selected pattern through the way of a press-forming step and successive heat treating steps is highly tedious and inefficient. For carrying out the local quench and temper steps above referred to, the high frequency heating technique is predominantly employed which will invite a large amount of investment for the costly current supply appliances, in addition, indeed, to a highly complicated design of the heating coil means.

It is the main object of the invention to provide a highly improved process for the manufacture of the

product of the kind above referred to, capable of substantially obviating the aforementioned various conventional drawbacks.

A further object is to provide an improved process of the kind referred to above, whereby the hitherto separately carried out press-forming job and the heat treating job can be united into a single step.

A still further object of the invention is to provide an improved product having several surface areas of different hardnesses of a specifically selected pattern as is required for an automotive diaphragm spring.

For fulfillment of the aforementioned objects, the process according to the invention for the manufacture of a product having a specifically selected mechanical shape provided by press-forming job and its whole surface area divided into local areas of which a local area has a higher value of hardness substantially equal to that obtainable by a conventional quenching job and a further one of said local areas has a lower value of hardness substantially equal to that obtainable by a conventional tempering job, is carried out in such way that the stock is preparatorily heated up to its hardening temperature and then the stock is subjected to a combined press-forming and heat-depriving step by contact with at least a pair of mating die elements.

These and further objects, features and advantages of the invention will become more apparent when read the following detailed description of the invention by reference to the accompanying drawings.

In the drawings:

FIGS. 1 and 2 are a plan view and a side view of the product manufactured by the process according to this invention and indeed, in the form of an automotive clutch diaphragm spring.

FIG. 3 is an elevational view of a preferred embodiment of the machine adapted for performing the process according to this invention.

FIG. 4 is a sectional view of a pair of cooperating working dies employed on the machine showing in FIG. 3.

FIGS. 5 - 7 are explanatory charts for clarifying the nature of the invention.

Referring now to the accompanying drawings, a preferred embodiment of an apparatus adapted for carrying out the process according to the present invention, and a preferred product by way of example of an automotive clutch diaphragm spring prepared by said process on the said apparatus will be described in detail.

The clutch diaphragm spring is shown most clearly in FIGS. 1 and 2 generally at 100. This spring 100 represents in its plan configuration as shown in FIG. 1, a circular disc having an outer peripheral spring zone 101, a number of, 16 in the specific embodiment product shown, radial arms or levers 102 extending from said outer spring zone 101 towards the center of said disc and said levers having equal lengths so as to define substantially a circular central opening at 100c when imaginably connecting the straight-edged end extremities 100b of these levers 102, each of the latter having a substantially elongated and truncated trapezoid. An end part 103 of the lever 102 must have a highest hardness so as to provide a high wear resistance value, since this end part in its working position in the automotive clutch is kept in pressure contact with a

clutch release bearing. The diaphragm spring 100 represents thus a rotary symmetry, its outermost peripheral margin 100a representing a complete circle. The spring zone 101 must have a lower hardness and a proper value of elasticity, so as to act as a spring part when seen as a whole. Generally, the diaphragm spring is made of a tool steel sheet 2-3 mm thick. Between each two neighboring levers 102, there is formed a narrow idle gap 100d, the outermost extremity thereof corresponding the root ends of these levers being enlarged so as to provide a small radially elongated elliptical opening 100e adapted for prevention of otherwise possible radial cracks as may be encountered in practical use of the diaphragm spring.

A centrally perforated, generally circular disc sheet stock serving for the preparation of the diaphragm spring is shown in its diametral section at 100' in FIG. 4. This stock or semiproduct, its general plan configuration corresponding to that of the finished product shown in its plan view in FIG. 1, has been pressed out beforehand from a sheet stock, tool carbon steel, class 5 (JIS SK5), about 2 mm thick, the outer diameter being about 170 mm in the present specific embodiment. The general sectional configuration is a centrally perforated plate as seen.

This stock 100' is subjected to a combined press-forming and heat-depriving step on an apparatus in the form of a die press shown in FIGS. 3 and 4 into the final product shown in FIG. 2 when seen in its side elevation having a general shape of truncated cone. This finished product 100' has a different hardness distribution representing, as a whole, three concentric circular zones when seen in its plan view as shown in FIG. 1. The innermost or first ring zone extending over a radial distance of about 20 mm as measured from the tip edges 100b of levers 102 and including lever end parts 103. The lever end 103 has a higher hardness range H_{RC} 60-70, while the spring zone 101, the innermost periphery thereof being positioned at a distance about 40-70 mm as measured from the tip end 100b of the lever 102, has a lower hardness H_{RC} 40-45.

Next, referring to FIGS. 3 and 4, the apparatus adapted for carrying out the process will be described hereinbelow in detail.

The numeral 1 represents a stationary bed from which four upright columns 2 extends fixedly extend upwards. On the drawing, however, only two of these columns 2 are seen. The upper ends 2a of these columns 2 are fixed together by an upper plate 3. A hydraulic cylinder 4 is fixedly mounted on the upper plate 3; the upper interior working chamber, not shown, of the cylinder 4 is connected by a piping 5 have an on-off control valve box 6, to an oil pump leading to a supply source, although not specifically shown.

A ram 7 is mounted on columns 2 so as to be slidable therealong and connected rigidly with a piston rod 8 extending sealingly from a hydraulic piston, not shown, slidably contained in the interior space of the cylinder 4. The lower working chamber, not shown, of the cylinder 4 is connected with a piping 45 which passes through the valve box 6 for on-off control of oil supply and discharge to and from the lower cylinder working chamber.

Numerical 9 represents an upper die unit which is fixedly attached by means of a plurality of fixing bolts 12

and through an insulator board 13 to the lower surface of a die holder plate 11 detachably attached in turn to the lower surface of ram 7 by means of fixing bolts 10.

The upper die 9 comprises a hollow outer ring-shaped die element 90 and a centrally positioned hollow die element 91. The insulator board 13 is centrally perforated so as to represent practically a ring, for receiving a central insulator disc 15 which is detachably attached to the plate 11 from below by means of a plurality of fixing screws 14. The upper central die element 91 is sealingly attached through sealing ring means 16 to insulator disc 15 by means of a plurality of fixing screws. A ring-shaped idle gap space formed between the die elements 90 and 91 is filled with insulator material 18. Outer die element 90 is surrounded by a protecting and insulating ring 18' as seen.

A mating lower die unit is shown generally at 19. This unit 19 comprises an outer hollow die element 190 which is detachably attached through an insulator ring board 23 fixedly attached in turn to a die holder plate 21 by means of a plurality of fixing bolts 22. The holder plate 21 is fixedly attached to the bed 1 by means of a plurality of fixing bolts 20. A central insulator disc board 25 is inserted in the central bore of outer ring insulator 23 and fixedly attached to the outer surface of plate 21. Between the die elements 190 and 191, there is formed a ring-shaped idle gap space is filled with an insulator ring 28. The outer die element 190 is enclosed from outside by a protecting and insulating ring 28'. Between insulators 23 and 25, there is provided a sealing means 26. Fixing bolts for the central die element 191 are shown at 27.

The upper and lower dies 9 and 19 are formed in their mutually corresponding shapes. More specifically, the upper die 9 represents a male configuration and the lower die 19 represents a corresponding female configuration. Outer die elements 90 and 190 have also mutually corresponding shapes so as to allow their mutual mechanical cooperation. This feature is naturally applied to the central by arranged die elements 91 and 191.

Outer die elements 90 and 190 are formed with respective tapered and ring-shaped working surfaces 92 and 192 cooperable with each other. Similarly, central die elements 91 and 191 are formed with respective and correspondingly shaped convex and concave working surfaces 96 and 196. The common taper formed by the upper working surfaces 92 and 96, and by the lower working surfaces 192 and 196 is selected to that of the finished product which is represented by the cone surface thereof.

Lower outer die element 190 is formed at its upper and outer periphery with a ring projection 193 which is adapted for engagement with a correspondingly shaped ring recess 93 formed on the lower and outer periphery of the upper and outer die element 90.

A central hollow projection 197 having an outer diameter substantially equal to the central opening 100c formed at the center of the finished product and adapted to engage in a central guide recess 97 formed on the upper central die element 91.

As will be more fully described hereinafter, the couple of upper and lower outer die elements 90 and 190 constitute in combination a first cooperating pair of heat-retrieving elements. In the similar way, the upper

and lower central die elements 191 constitute in combination a second cooperating heat-retrieving elements.

It will be seen thus that there are provided two cooperating upper and lower heat-retrieving units in the respective die units on the press machine, each of these units having concentrically arranged outer and inner or central elements kept in heat insulation from each other and the common outer surface of each of these heat-retrieving units acts as the press-working surface of either press-forming die units 9 and 19, respectively, thereby providing the desired final cone shape of the product.

Each combination of the outer and central heat-retrieving elements 90 and 91 or 190 and 191 serve as cooler means of different temperatures for the stock 100' to be processed upon. The respective upper and lower ends of the outer elements 90 and 190 are made originally open, but in the assembled position shown, these opened ends are closed by ring board insulators 13 and 23, respectively, so as to provide respective inner hollow spaces 94 and 194 in the elements 90 and 190.

In these hollow spaces, there are provided sheath heater elements 30 and 30', respectively, which are connected respective conductor means 29 and 29' to a certain current source, not shown.

Feeding and return elements of these conductor means 30 and 30' are guided through respective openings 95 and 195 bored through the respective outer walls of the elements 90 and 190, and related terminal boxes 31 and 31' fixed on the outer surfaces of these walls, although their insulating sheaths have been omitted only for simplicity.

Upon fitted these sheath heaters 29 and 29' in the respective cavities or inside spaces 94 and 194, these spaces are filled with respective masses 32 and 32' of insulating material for assuring the proper positioning of these heaters and for the prevention of heat radiation in undesired directions, thus improving the overall heat balance of the machine. Blind bores 33 and 33' are formed through insulators 18', 28' and part of the material of the outer elements 90 and 190 near to their working surfaces for reception of conventional thermocouples 34 and 34', respectively. These thermocouples 34 and 34' are leaded out at 35 and 35', respectively, to a die temperature control unit, not shown, for keeping these outer die elements at a certain predetermined value corresponding at least to the isothermal transformation temperature of the stock material.

The inner or central die elements 91 and 191 are formed to open towards the opposite dies, respectively, and the open ends of these die elements are closed by the upper and the lower central insulator disc boards 15 and 25, respectively, so as to form therein inside water chambers 98 and 198, respectively.

Inlet mouth piece 99 and outlet mouth piece 199 are provided within these water chambers 98 and 198, respectively, and fixedly mounted with their root ends on the respective insulator discs 15 and 25 at the centers thereof, while the free ends of these mouth pieces open towards the working surfaces of the central die elements 91 and 191, respectively.

Conduit 36 is formed through outer and central insulator boards 23 and 25 of the lower die unit 19 and the

inner end of said conduit opens into the lower water chamber 198, while the outer end of said conduit is tightly connected with a supply piping 40 leading to a certain cooling water supply source, not shown.

A similar conduit 37 is formed horizontally through central and outer insulator boards 23 and 25; the inner end of said conduit is tightly connected with the root end of discharge mouth piece 199, while the outer end of said duct is connected tightly with the lower end of a flexible tubing 41.

In the upper die unit 9, a conduit 38 is formed through outer and central insulator boards 13 and 15; the inner end of said duct is tightly connected with root end of said inlet mouth piece 99, while the outer end of said duct is tightly connected with the upper end of said tubing 41.

A similar conduit 39 is formed horizontally through insulator boards 13 and 15; the inner end of said duct opens into the inside water chamber 98 of the upper central die element 91, while the outer end of said duct is tightly connected with the inner end of a flexible tubing 43 which leads to a discharge piping 42, FIG. 3, which is connected with a certain vessel, not shown. Water supply control valve 44 is provided in the piping 40 as seen from FIG. 3. By manipulating this valve 44, the flow rate of circulating cooling water through water chambers 98 and 198 can be controlled. The main constituent parts of the upper and lower die units 9 and 19 are made of the standard machine steel, carbon steel JIS S45C, for providing an efficient thermal conductivity and a favorable mechanical strength.

In the following, a preferred numerical example for carrying out the process according to this invention will be described in detail in case of the manufacture of an automotive clutch diaphragm spring shown in FIGS. 1 and 2 by way of example.

At first, a preparatorily punched out, centrally perforated steel disc stock 100' having a number of radially extending arms having a general plan configuration similar to that shown in FIG. 1, the material being a kind of tool carbon steel, SK-5 (JIS), is introduced in a furnace so as to heat it at 830°C for about 20 minutes. Then, the stock is taken out from the furnace and placed in the uppermost part of a coned recess formed by the upper working surfaces 192 and 196 of the lower die elements 190 and 191 of lower die unit 19 shown in FIG. 4 by bringing the central bore 100c of the stock 100' into engagement with the central guide projection 197 on the lower central die element 191. Next, by manipulating control valve box 6, pressure oil is introduced into the upper working space of hydraulic cylinder 4, for lowering the hydraulic piston contained therein.

Motion is therefore transmitted from the piston through its rod 8 to ram 7 which is thus lowered together with upper die unit 9 towards the mating lower die unit 19, until the stock 100' is pinched by these die units and subjected to a forced and pressure deformation into a cone as shown in FIG. 2, the thus brought about cone configuration of the stock being naturally defined by the cooperation between the convex cone-shaped projection provided by the working surfaces 92 and 96 of the upper die elements 90 and 91, on the one hand, and the concave cone-shaped cavity provided by the working surfaces 192 and 196 of the lower die ele-

ments 190 and 191. The pressure impressed upon the stock 100' amounts to 25 kg/sq. cm by way of example.

The upper and lower outside die elements 90 and 190 have beforehand been heated up to about 420°C which corresponds to the isothermal transformation temperature of the stock material employed specifically in this case. On the other hand, the upper and lower central die elements 91 and 191 have beforehand kept at about 25°C by manipulating the on-off control valve 44 so as to allow cooling water to circulating through the lower and upper water chambers 198 and 98.

It will be thus clear from the foregoing that the stock 100' is subjected simultaneously to a mechanical press-forming step and a heat-treating step wherein, however, different amounts of heat are deprived of at different zones from the stock. More specifically, the innermost circular area denoted "Q" in FIG. 1 which are defined by a specifically selected end part 103 of each diaphragm arm or lever 102 and kept in pressure contact with the upper and lower central die elements 91 and 191 from upper and below of the stock for subjecting to quench. In this inside circular zone "Q", the stock kept at its hardening temperature about 830°C is subjected to a quenching step. On the other hand, the outer ring-shaped zone "R" of the stock which zone is kept in pressure contact with the outer die elements 90 and 190 from upper and below of the stock. These die elements are kept at about 420°C as above referred to. The stock is rapidly cooled at the outer ring zone "R" from about 830°C to about 450°C and then kept substantially at this temperature, so as to be subjected to an isothermal heat treatment.

After keeping the stock under pressure of 25 kg/sq. cm between the upper and lower die units 9 and 19 in this way for about 30 seconds, the control valve box 6 is manipulated to initiate a reversed oil flow to and from the cylinder 4 as known per se, so as to elevate the hydraulic piston contained therein for receding the upper die element from its working and cooperating position with the lower die unit to its idle one which is illustrated in FIGS. 1 and 2. Then, the finished product in the form of a ready-for-use automotive diaphragm spring 100 can be taken out from the die press.

The aforementioned heat-treating step which has been performed simultaneously with the mechanical pressing job will be described more in detail by reference to FIG. 5, illustrative of a chart wherein the isothermal transition and the like temperatures have been plotted against time, the latter being shown in seconds and on a logarithmic scale. In this chart, "A" represents austenite region; "B" bainite region; "P" pearlite region; and "M" martensite region. Curve $a-b$ represents the initiation of transformation where the austenite structure begins to decompose, while curve $a'-b'-c'$ represents the termination of transformation. Curve $0-c$ (Ms) represents the initiation of formation of martensite structure. Curve $e-f-g$ or denoted "I" represents the transformation in the stock 100' when it is quenched from 830°C (cf., point e) in the innermost zone "Q" as was referred to above by keeping it in pressure contact with the central die elements 91 and 191 and nearly to the cooling water temperature. In this case, curve $e-f$ represents the quench step from the austenite state to the initiation line $d-c$ for the

generation of martensite structure, thence along the curve $f-g$ which represents the progress of generation of hard martensite structure. In this way, the inner end portion of the diaphragm arm is hardened sufficiently so as to enjoy a full degree of quench effect. Curve $e-h-j-k$, being denoted "II", represents the progress of the aforementioned isothermal transformation given to the spring part 101 of the finished diaphragm spring, by subjecting the outer ring region "R" of the stock quench from the hardening temperature of about 830°C (cf., point e) to nearly the cooling temperature or about 450°C (cf., point h) by contact with the outer die elements 90 and 190, and then keeping the stock at the thus attained lowest treating temperature. The curve $e-h$ represents the austenite structure emanated by the corresponding quench, and the curve $h-k$ represents the isothermal maintenance of the stock zone "R" at about 450°C, thereby advancing further across the transformation-initiating curve $a-b-c$ into the region "B". The austenite structure is decomposed and the stock zone will initiate the transformation into bainite. This transformation will further advance along the curve $i-k$ across the transformation-terminating curve $a'-b'-c'$ into the bainite region "B". In this way, it is possible to provide a lower hardness value to the spring zone 101 of the stock. Upon measured of the local temperatures of the finished product as taken-out, it was found that the temperature of the spring part 101 amounted to about 450°C and that of the lever ends was measured to substantially room temperature. When the finished and taken out diaphragm spring was placed in the open atmosphere, heat was dissipated from the spring part 101 till the room temperature, while the lever ends of the diaphragm were reheated by penetrated heat from the spring part 101 to a certain appreciable degree, but it was again cooled down to the room temperature, together with the spring part, as the time processed. In this course of the after-again so to speak, the quenched lever ends 103 were subjected to an spontaneous temper effect so that they acquired an additional toughness over the once quenched parts, while the heat-treated effects in the isothermally transformed spring zone 101 was not subject to alteration.

In the intermediate ring zone situated between the both zones "Q" and "R", defined by the main parts of the diaphragm levers 102, it was subjected substantially to an isothermal transformation with intermediate temperatures between those applied to the both zones "Q" and "R". Therefore, the main parts of lever 102 may represent proper values of hardness and toughness to be owned by these levers.

The hardness distribution as measured along a radius of the diaphragm spring thus finished diaphragm spring is shown by way of example in FIG. 6. The measured points were selected at 2 mm-intervals along a radius of the diaphragm spring as shown schematically at "S" in FIG. 1. The total number of these measured points amounted to 34. In the graph shown in FIG. 6, the measured hardness H_{RC} has been plotted against the distance as measured from the tip end of the related one of the levers 103. The range shown by a first double-heated arrow "X" represents the quenched zone "Q", while that covered by a second double-heated arrow "Y" corresponds to the isothermally treated zone "R". As seen, the quenched region "X" which

covers the lever ends 103 represents the hardness values higher than H_{RC} 60 which is the desired least one.

Within the range Y, the part thereof corresponding to an about 40–70 mm range covering the spring part 101, the hardness varies between about H_{RC} 40–45 which satisfies the required demands.

In the diagram shown in FIG. 7, two curves "Q" and "R" represents the hardness distribution along two circles having corresponding measuring points as shown in FIG. 1, being expressed again in terms of H_{RC} . From these hardness distribution curves, it will be seen that the quenched zone "Q" and the isothermally treated zone "R" represent respectively acceptably favorable hardness values. As shown, these series of practical hardness values represent no appreciable fluctuations.

After all, it can be concluded that according to the present inventive process, the diaphragm spring taken only by way of example has been heat-treated to a favorable and acceptable degree and, indeed, practically in a single processing step.

In the following table, comparison is made on automotive diaphragm springs of the kind above referred to, and between the thermal distortion appearing on the finished product according to the invention, and the corresponding product manufactured according to prior technique by successive steps of press-forming, quenching and distortion-relieving, so far as the final distortion is concerned.

TABLE

	Conven- tional Disfor- tion Measured Upon Oil Quench	Heat Treatment Disfor- tion Measured Upon Temper- ing	Inventive Process
Max. Undulation from True Plane Cone Base in mm	1.12	0.21	0.03
Max. Height Difference among Tip Ends of Diaphragm Spring in mm	3.61	0.68	0.25

The max. undulation from true plane cone base enlisted in the above Table was measured as the max. gap appearing by placing the finished product on a surface plate. When the gap is nil, the distortion concerned is also nil.

The max. height difference among the tip ends of the diaphragm spring enlisted in the above Table was measured the max. axial distance between the upper most and the lowermost lever tip ends of the finished diaphragm spring.

It will be seen from the foregoing that the thermal distortion appearing on the products manufactured by the process according to this invention wherein the mechanical press job and the localizedly different temperature heat-treatment are carried out in a sole processing step will amount only one-seventh to one-half of that appearing on the conventional products, wherein a tempering job is carried out additionally.

This more advantageous and superior effect over the conventional prior technique may be attributed to such

fact that in the former, the stock is uniformly cooled so far as the respective heat-treating zones having different thermal requirements are concerned and under the mechanically pressing conditions which prevents substantially otherwise possible disadvantageous invitation of thermal distortions of the finishing product, thus serving latently for a suppressing the generation of the thermal distortions.

The progress of the metallurgical transformation under the distortion-relieving pressurized conditions will thus provide a least minimum degree of the thermal distortions.

In the following, a comparison will be made on the thermal treatment status between the inventive process and the conventional one.

The comparative conventional process have required to adopt the following five steps as a whole, or more specifically, four steps even for the heat-treatments per se:

1. The centrally perforated and armed plane disc stock as at 100 is mechanically formed into a truncated cone shape, such as by a press-forming step.
2. The thus mechanically preshaped stock is heated up to about 830°C for about 20 minutes and then subjected to an oil quenching step.
3. A stress relief tempering step is made in such way that the stock is heated at about 320°C for about 90 minutes and air cooled, so as to reduce the quench hardness to a certain degree. This step is called the provisional temper.
4. The thus treated stock is tightly mounted in a job and then heated in a furnace at about 450°C for about 180 minutes, air cooled, for performing a distortion relief tempering job.
5. Lever ends 103 are high frequency hardened, heated at about 170°C for about 90 minutes and finally air cooled, so as to carry out a tempering job.

In comparison with the above mentioned prior process, the inventive process is carried out in the following two steps. More specifically, the stock is heated at about 830°C for about 20 minutes, and then, the thus heated stock is processed by placing it under pressure between a pair of mating die units, each having at least a cooled die element and at least a heated die element, so as to perform a press-forming step for bringing the stock into its final mechanical and truncated coned configuration, simultaneously with a heat-treating step for quenching the lever ends of the diaphragm and to subject the spring portion of the diaphragm to an isothermally treating step by contact with said heated die elements and said cooled die elements from upper and below of the stock which is now under mechanical shaping job.

In the foregoing, the description has been directed to performing of a combined press-shaping and heat-treating step on a plane sheet stock. It is naturally possible to heat-treating a preparatorily press-formed cone stock of truncated shape is subjected to the aforementioned complex heat-treatment for obtained the desired hardness distribution.

In the foregoing description, a part of the die elements was kept at a certain higher temperature and a pair of said die elements is water-cooled nearly to the normal temperature, said thermally different die ele-

ments being thermally insulated from each other for obtaining better results. Under circumstances, however, one end of upper or lower die unit is kept at a heated temperature, while the other end of the same die unit is kept at a properly selected temperature, thus providing a continuous temperature slop therebetween. In this case, the hardness distribution on the related part of the final product may vary in a gradual and continuous change.

Although in the following description, the manufacture of automotive diaphragms has been referred to. However, the present invention is not limited only thereto. Various other kinds of products can be manufactured without departing the scope and spirit of the appended claims. For instance, the inventive process can be applied to the manufacture of automotive clutch disc plates.

It may be easily supposed that the hydraulic piston-and-cylinder means 4 may be connected with the lower die unit in place of the upper die unit, although not specifically shown.

Or alternatively, a further such means similar to that shown at 4 may be attached additionally to the foregoing one illustrated.

The embodiments of the invention in which an exclusive property or privilege is claimed are as follows:

1. A process for the simultaneous shaping and heat treating of steel sheet stock comprising preheating said stock up to its hardening temperature, pressing said stock into the desired form between two mating die units and simultaneously heat treating said stock by subjecting said stock to a differential heat deprivation

effect by maintaining at least two distinct complementary portions of said die units at different temperatures lower than said hardening temperature.

2. A process as set forth in claim 1 further comprising maintaining one of said portions of said die units at a constant temperature corresponding to the isothermal transformation temperature of the stock material and cooling another of said portions of said die units to perform a quenching operation on said stock material.

3. An apparatus for performing a combined press-forming and heat-treating operation on preheated steel sheet stock comprising a pair of complementary upper and lower die units, each of said die units having a working surface corresponding to that of the related part of said stock when finished into a product, each of said units having at least two separate die elements, means for bringing said die units into and out of operative engagement with said stock, and cooling means for cooling at least one pair of complementary upper and lower die elements corresponding to a first selected zone of said stock thereby removing heat at a higher rate from said first selected zone of said preheated stock and at a slower rate from the remaining portion of said stock.

4. An apparatus as set forth in claim 3 further comprising heating means for heating at least another pair of complementary die elements to a temperature less than the preheated temperature of said stock whereby heat will be removed from a second selected portion of said preheated stock to a lesser degree than from said first selected portion of said preheated stock.

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