Feb. 11, 1969 H. JANSEN ETAL 3,426,564

ELECTROMAGNETIC FORMING APPARATUS

Filed May 31, 1967

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FIG. 1.

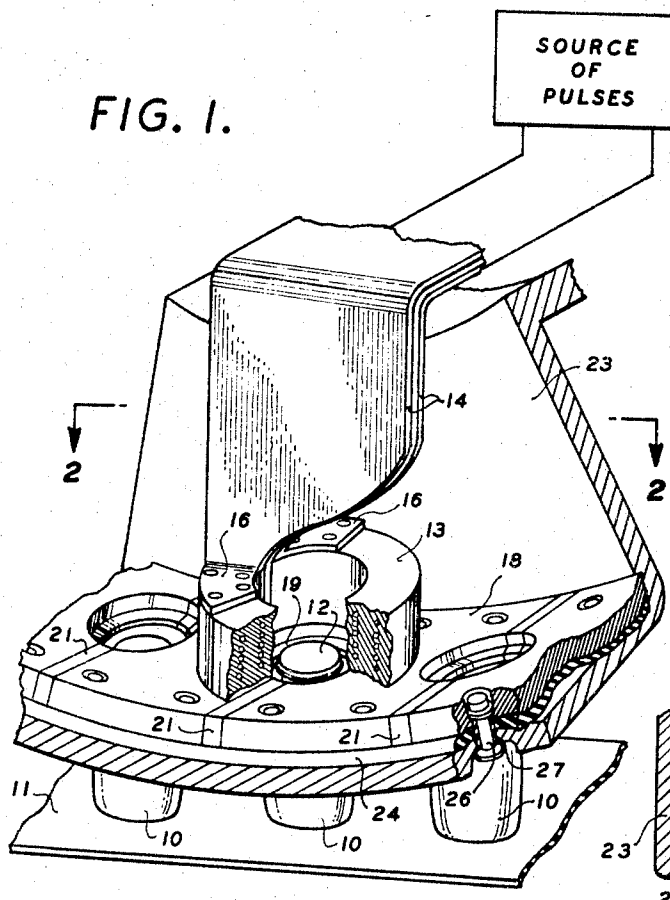
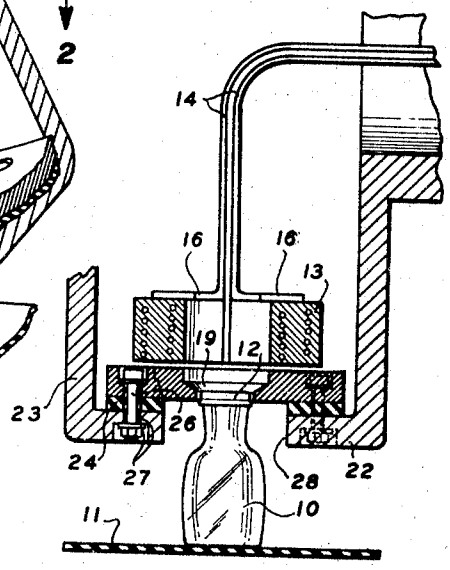


FIG. 3.



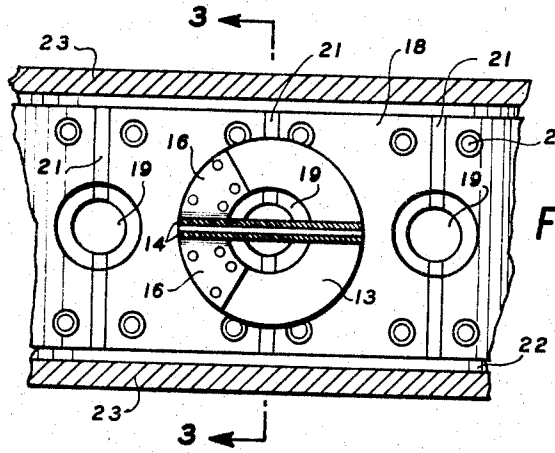


FIG. 2.

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FIG. 4.

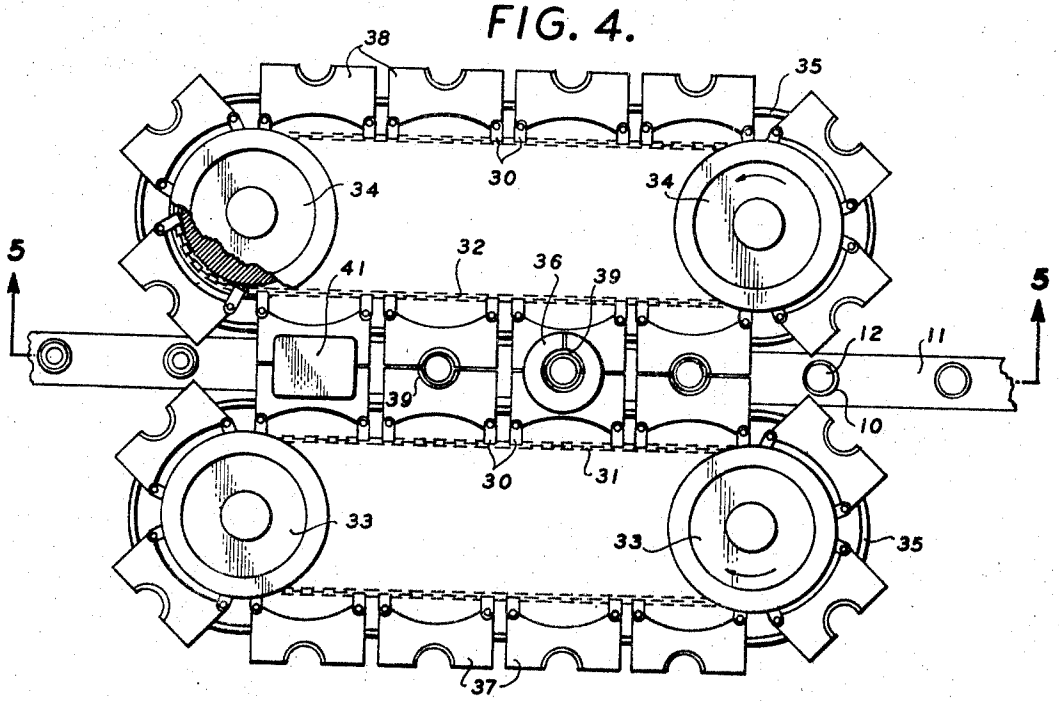
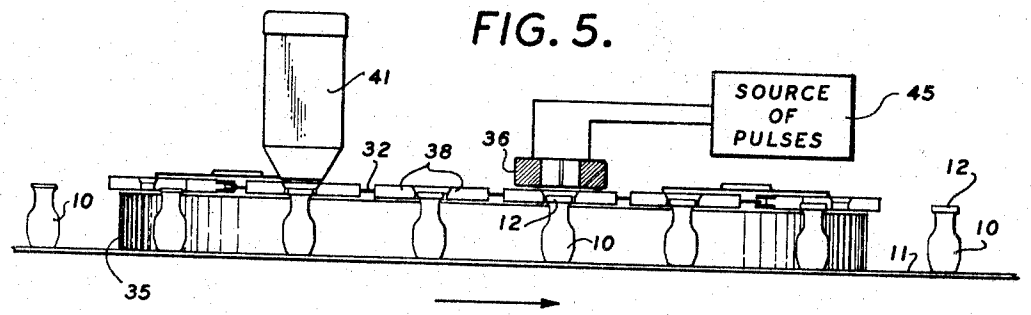


FIG. 5.



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ELECTROMAGNETIC FORMING APPARATUS

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FIG. 6.

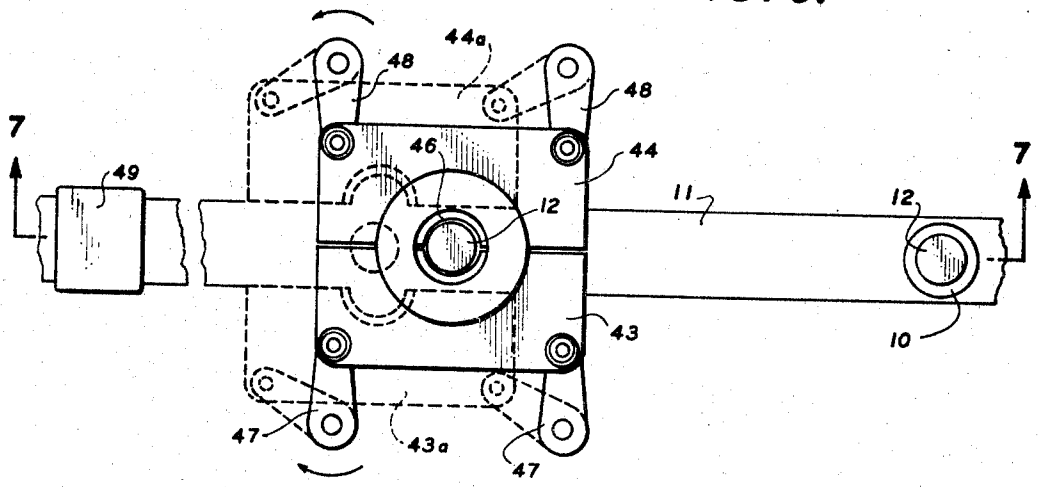
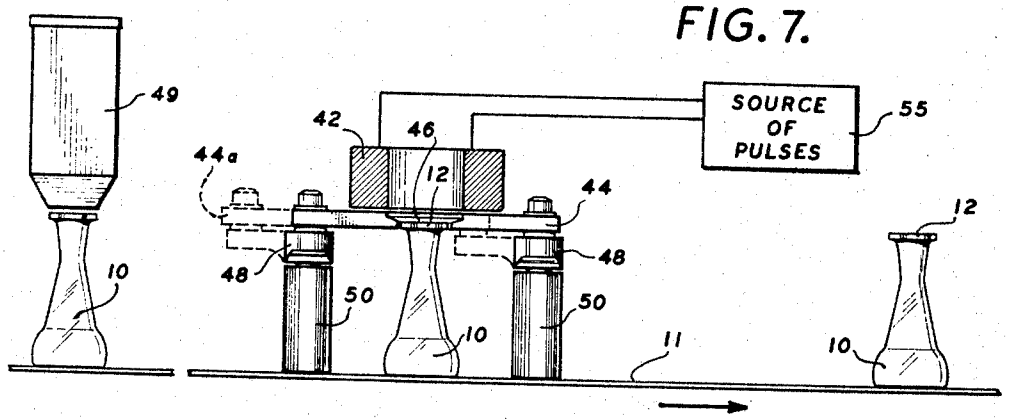


FIG. 7.



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3,426,564

ELECTROMAGNETIC FORMING APPARATUS

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U.S. Cl. 72—56 7 Claims
Int. Cl. B21d 26/02, 19/00; B65d 7/28

ABSTRACT OF THE DISCLOSURE

Apparatus for electromagnetically forming a plurality of work pieces moving in succession in a given direction, wherein apertured field shaper or shapers are positioned about and moved with the work pieces into operative relationship with a stationary forming coil.

The present invention relates to electromagnetic forming apparatus and particularly to electromagnetic forming apparatus for forming a plurality of work pieces moving in succession along a path of travel.

Under some circumstances, such as in some types of mass production systems, it is necessary or desirable to form a plurality of work pieces which are moving in succession in a given direction. A particular example of such a system is in the attachment of closures to containers, such as where a plurality of bottles or jars are moved at a high rate on a linear conveyor from a filling station through a capping station to a packaging area. Mechanical contrivances for attaching such closures may be unduly complex and difficult of adjustment due to the desirability of high speed operation and of avoiding damage to the containers.

In view of the aforementioned difficulties with mechanical contrivances, a significant advantage is provided by forming the work piece through employing transient magnetic fields of high intensity. An example of magnetic forming apparatus may be seen in the U.S. Patent No. 2,976,907, issued Mar. 28, 1961, and assigned to the assignee of the present invention. In apparatus of this general type, an electrical current pulse of high amperage is passed through a conductive coil, thereby producing a transient magnetic field of high intensity. A conductive work piece positioned in the transient magnetic field has a current induced in it corresponding to the changing flux of the transient magnetic field. The induced current interacts with the magnetic field to produce a force acting on the work piece. If the force is sufficiently strong, a deformation of the work piece results. The shape of the deformation is dependent upon the shape of the magnetic field and the position of the work piece relative to the field.

In order to compress part of a closure, such as the annular flange of a bottle cap, inwardly against the container to which the closure is to be attached, it is usually necessary that the means which produce the magnetic field surround the compressible part of the closure. This may be accomplished by disposing the closure inside the magnetic coil, or inside the aperture of a conductive plate. In the latter case, the conductive plate, which is sometimes referred to as a field shaper, is disposed relative to the coil such that the transient magnetic field produced by the coil induces a current in the field shaper which is concentrated on its inner surface around the aperture. The current pulse flowing on the inner surface of the field shaper create a transient magnetic field in the aperture for forming the closure.

The positioning of the closure or similar work piece in the proper location within the magnetic coil or field shaper aperture may present difficulty, particularly in connection with a plurality of work pieces moving in succession in a given direction, such as along a conveyor as used in many mass production systems. One way of accomplishing such positioning is to move the work piece in the direction of the axis of the coil or of the aperture in the field shaper. In container capping or similar operations, this usually necessitates movement of the container and cap transversely of the motion of the mass production line. The accelerations required for this type of motion become very considerable where high speed conveyors are utilized, rendering the design of required mechanisms for such a motion complex and difficult. Furthermore, there is, because of these accelerations, a danger of spillage of the contents of the container.

Alternatively, it is possible to move the forming apparatus toward each work piece to be formed until the work piece is properly positioned in the transient magnetic field. Movement of the coil, however, adds considerable complication to its design and the attainment of consistently reliable forming may be difficult in such apparatus.

It is an object of this invention to provide improved magnetic forming apparatus.

Another object of the invention is to provide improved apparatus for attaching closures to containers while such containers are moving on a linear conveyor or similar device.

A further object of the invention is to provide apparatus for forming a plurality of work pieces moving in succession in a given direction, which apparatus utilizes a stationary coil and does not require movement of the work pieces transversely of the given direction.

The electromagnetic forming apparatus of the invention operates to form a plurality of work pieces moving in succession in a given direction. The apparatus comprises coil means adapted to be mounted in a fixed position with respect to the moving work pieces. Field shaping means are provided which define at least one aperture for accommodating respective work pieces. Means are provided for moving the field shaping means transversely of the given direction to repeatedly position the aperture about successive ones of the work pieces, and for moving the field shaping means in the given direction with the aperture positioned about a work piece to bring the aperture into an operative relationship with the coil means once for each work piece. Means are also provided for repeatedly applying pulses of electrical energy to the coil means each time the aperture is in operative relationship therewith to form the work piece therein.

Other objects of the invention will become apparent to those skilled in the art from the following description taken in connection with the accompanying drawings wherein:

FIGURE 1 is a perspective view of a portion of apparatus constructed in accordance with the invention;

FIGURE 2 is a sectional view taken along the line 2—2 of FIGURE 1;

FIGURE 3 is a sectional view taken along the line 3—3 of FIGURE 2;

FIGURE 4 is a schematic plan view of a further embodiment of the invention;

FIGURE 5 is a sectional view taken along the line 5—5 of FIGURE 4;

FIGURE 6 is a schematic plan view of a still further embodiment of the invention; and

FIGURE 7 is a sectional view taken along the line 7—7 of FIGURE 6.

Referring now more particularly to FIGURES 1 through 3, a plurality of bottles **10** are disposed upon a linear belt type conveyor **11** and are moved through a work station. Prior to arriving at the work station, each bottle has a cap **12** of conductive material placed thereon by a suitable cap feeder, not shown.

The work station is aligned with the axis of an electromagnetic coil **13**. The coil **13** is formed of a single turn of high strength conductive material and is supported above the work station by a pair of combination conductor-supports **14**. The supports **14** are attached to the coil **13** by brackets **16**, one disposed on each side of the gap in the coil. The conductors **14** are spaced from each other and operate to conduct a pulse of electric current to the coil **13** for establishing a transient magnetic field. Such a current pulse is produced by a suitable pulse source **15**, in which the pulses are timed as described below.

In order to secure the cap on the bottle without the necessity of stopping and accelerating the bottles into the magnetic field established by the coil **13**, the apparatus employs a plurality of field shaper plates **18**. The adjacent edges of the plates **18** are appropriately formed such that the plates define a plurality of apertures **19**. The apertures thus defined are of a configuration and size to produce the desirable magnetic forming of the bottle caps **12**. The transient magnetic field produced by the coil **13** induces a current which flows around the surface of the one of the apertures **19** which is at the work station. This produces a magnetic field which interacts with the conductive material of the bottle cap **12** to induce a current therein and provide the forming action as previously described. In order that the induced current will flow around the surfaces of the apertures, the adjacent plates are separated from each other at the apertures by strips **21** of insulating material.

The shaper plates **18** are arranged along the inner surface of the rim **22** of a rotary drum **23**. The plates **18** are separated from the inner surface of the rim **22** by a strip of insulator lining **24**. The plates are bolted to the drum by bolts **26** which are provided with a sleeve and washer **27** of insulating material. The lower surface of the coil **13** is spaced slightly from the plates **18** and is shaped to follow the curvature of the surface of the plates **18**. The rim **22** has a circumferential slot **28** formed therein to enable the bottles **10** to pass along beneath the drum in a straight line and project up into the apertures **19**.

The drum **23** is mounted for rotation by suitable means, not illustrated, and the supports **14** for the coil are carried out through the opening in the hub support of the drum. The pulse source **15** is coupled to the conductors **14** for applying electrical current to the coil **13**. Triggering of the pulse source is synchronized with the rotation of the wheel so that the coil **13** is pulsed each time an aperture moves into alignment with it. This can be achieved by mechanical means (not shown) such as a sliding contact or by photo cells or other suitable means.

The diameter of the drum **23**, the spacing of the apertures **19**, and the spacing of the bottles **10** on the conveyor **11** are selected such that the apertures will move down and surround the periphery of each cap as the bottles pass along underneath the drum on the conveyor. At the work station, the plates have a tangential velocity which is substantially the same as the velocity at which the conveyor is moving so that the cap will be properly centered in the aperture at the time of forming. The fact that the plates are mounted on a cylindrical drum causes the apertures to be moved with a component of movement transversely of the movement of the bottles **10** to bring the apertures into position over the caps **12** and to raise them away from the caps once forming is completed to permit the bottles to continue in their passage along the conveyor **11**.

Referring to FIGURES 4 and 5, a further embodiment of the invention is shown in which caps **12** are attached to the bottles **10** as they move along in succession on a linear type conveyor **11**. The embodiment is illustrated schematically and comprises a pair of conveyor chains **31** and **32**. The chain **31** is driven by a pair of sprockets **33** and, similarly, the chain **32** is driven by a pair of sprockets **34**. The chains **31** and **32** are moved at substantially the same speed and are disposed so that portions thereof are adjacent each other at a work station. The work station is aligned with the axis of a forming coil **36**. The coil **36** may be mounted by means (not shown) similar to those utilized in the previous embodiment and is thereby stationary relative to the movement of the chains **31** and **32** and the conveyor **11**. A source **45** of pulses is connected to the coil and supplies timed pulses as described below. Prior to the work station, a cap feeding mechanism **41** deposits the caps on the bottles in the desired position for attachment thereto.

A plurality of field shaper plates **37** and **38** are provided on each of the chains **31** and **32**, respectively. The plates are mounted to the respective chains by arms **30**. The arms are pivotally attached to the plates and flexibly secured on spaced links on the chains. The plates are supported from underneath on tracks **35**. At the adjacent portions of the chains, the plates are brought together in pairs and cooperate to define apertures **39** disposed about the respective caps **12** on the bottles **10**. The speeds of the chains **31** and **32** are selected to conform, at their adjacent portions, with the speed of the conveyor such that the pairs of plates **37** and **38** and the apertures **39** defined thereby move with the bottles with which they are associated. As the plates move through the work station adjacent the coil **36**, an electrical pulse is applied to the coil **36** from the source **45** in order to accomplish the forming of the associated cap on the bottles. The timing of the pulses produced by the source **45** is synchronized with the chain speed so a pulse is applied as each aperture moves into alignment with the coil.

As an alternative to the embodiment illustrated in FIGURES 4 and 5, it is possible to arrange the plates **37** and **38**, respectively, around the peripheries of a pair of wheels, rather than on chains as shown. With the wheels turning in opposite directions and positioned such that the plates thereon will come together in the desired paired relationship at a work station, a similar forming operation may be carried out.

It should be noted that in both the suggested alternative and in the illustrated embodiment of FIGURES 4 and 5, the plates do not contact each other. Contact may be prevented by a suitable insulating strip (not illustrated), or may be avoided merely by maintaining an air gap between the two plates. The reason for this is to insure that the conductor constituted by the surface around the apertures will not be equivalent to a shorted turn and thereby fail to produce the desired magnetic field.

Referring now to FIGURES 6 and 7, a still further embodiment of the invention is illustrated for attaching the caps **12** on the bottles **10** moving along the linear conveyor **11**. The embodiment includes a coil **42** which is mounted in a fixed position relative to the movement of the bottles by suitable means similar to that utilized in the previous two embodiments. A pair of shaper plates **43** and **44** are formed to define an aperture **46** when the two plates are adjacent each other. With the plates separated as is shown in the illustrated phantom positions (designated *43a* and *44a*), the aperture is such that it is in two separated halves.

The plate **43** is mounted on a pair of cranks **47**. Similarly, the plate **44** is mounted on a pair of cranks **48**. The cranks **47** and **48** are mounted on supports **50**. The cranks **47** are rotated by suitable driving means, not illustrated, in a clockwise direction as viewed in FIGURE 6, whereas the cranks **48** are rotated, by similar means, in a counterclockwise direction as viewed in FIGURE 6. With the cranks and plates properly positioned, the plates will move through a loop path which will successively bring the plates together to a relationship wherein the aperture **46** is not separated. It should be noted that the plates are never brought into contact, but an insulating gap is maintained therebetween to insure production of the desired magnetic field within the aperture **46**.

The positioning of the plates is such that they are in their closest position at the work station, that is, with the axis of the aperture **46** aligned with the axis of the coil **42**. At such a position, the aperture **46** is in an operative relationship with the coil. As the plates are brought together, the crank speed is such that a bottle cap **12** will be in the aperture **46** and in alignment with the coil **42** at the work station. A source of pulses **55** supplies a pulse to the coil in this position to attach the cap to the bottle.

The crank speed must be made proportional to and synchronized with the speed of the bottles. Since there are only two plates, the distance between bottles may have to be kept too large. If shorter distances or higher flow rates are required at the same bottle speed, an additional device or devices identical with that illustrated may be placed further along the conveyor **11**. The timing of all the devices may be such as to each form every second or third or *n*th caps, depending upon the number of devices utilized. A suitable cap feeding mechanism **49** is placed ahead of the devices in order to deposit caps in proper position on the bottles.

It will therefore be seen that the invention provides an improved forming apparatus and, particularly, improved apparatus for attaching closures to containers while the containers are moving on a linear type conveyor. In the apparatus of the invention, movement of the forming coil is unnecessary. Accordingly, the coil may be mounted securely in a fixed position and may be of simplified design and support relative to a device wherein a moving coil is required. Moreover, it is unnecessary in the apparatus of the invention to move the work pieces transversely of their movement on the linear conveyor. As a result, there are no problems involved with spillage of contents or of design of complex apparatus for effecting the necessary transverse accelerations at high production rates. The invention accomplishes its purpose by utilizing field shapers which are mechanically conveyed through a work station and into an operative relationship with the work pieces and the forming coil. The shapers are then moved away from the work pieces in order to permit the work pieces to continue on a linear path on the conveyor.

Various embodiments other than those illustrated herein will become apparent to those skilled in the art from the foregoing discussion and accompanying drawings. Such other embodiments, and modifications thereof, are intended to fall within the scope of the appended claims.

What is claimed is:

1. Apparatus for forming a plurality of work pieces moving in succession in a given direction, comprising coil means adapted to be mounted in a fixed position with respect to the moving work pieces, field shaping means defining at least one aperture for successively accommodating work pieces, means for moving said field shaping means transversely of the given direction to repeatedly position said aperture about successive work pieces, and for moving said field shaping means in the given direction with said aperture positioned about a work piece to bring said aperture into an operative relationship with said coil means once for each work piece, and means for applying a pulse of electrical energy to said coil means each time said aperture is in operative relationship therewith to form a work piece therein.

2. Apparatus in accordance with claim **1** wherein said moving means are rotary and move said field shaping means in a loop having an orientation such that movement of the field shaping means has one component transverse to the given direction and one component in the given direction.

3. Apparatus in accordance with claim **2** wherein the velocity of said field shaping means in the given direction when said field shaping means are in operative relationship with said coil means is substantially equal to the velocity, in the given direction, of the work piece about which said aperture is positioned.

4. Apparatus in accordance with claim **1** wherein said moving means comprise a rotary drum and wherein said field shaping means comprise a plurality of apertured plates arranged about the periphery of said drum and being substantially parallel with the axis of rotation thereof, said drum being adapted for positioning with its axis of rotation oriented transversely of the given direction to cause said work pieces to enter said apertures successively at a work station, said coil means being positioned at said work station to successively be in operative relationship with said apertures thereat.

5. Apparatus in accordance with claim **1** wherein said field shaping means comprise a plurality of plates adapted to cooperate in at least one pair at a work station such that each pair defines an aperture, and wherein said moving means comprise first conveyor means for moving one of said plates in each pair in a loop path, said moving means further comprising second conveyor means for moving the other one of said plates in each pair in a loop, said first and second conveyor means having adjacent portions movable in substantially the same direction and at substantially the same speed at the work station and being positioned to cause said work pieces to be accommodated by said apertures at the work station, said coil means being positioned at the work station to successively be in operative relationship with said apertures thereat.

6. Apparatus in accordance with claim **5** wherein said first and second conveyor means comprise generally coplanar endless type conveyors adapted to be positioned on opposite sides of the moving work pieces, and wherein a plurality of field shaper plates are carried by each conveyor.

7. Apparatus in accordance with claim **5** wherein said field shaping means comprise two plates adapted to be positioned adjacent each other at the work station to define an aperture, and wherein said moving means comprise rotary cranking means secured to each of said plates.

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U.S. Cl. X.R.

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