ABSTRACT: Apparatus and method for producing magnetic cores comprising forming a mixture of magnetic particles and a binder into a sheet, punching a ring-shaped die through the sheet to form a disc, punching a coring die through the disc and into the hole of the ring-shaped die to form a toroid, heating the toroid to remove the binder, and heat-treating the toroid to give it its final magnetic properties.
MAGNETIC CORE FORMING SYSTEM

BACKGROUND OF THE INVENTION

The present invention relates to a method and apparatus for producing magnetic cores of ferrite materials suitable for magnetic-core data storage devices.

In the manufacture of magnetic cores suitable for use in memory devices, generally a load of a mixture of a powdered ferrite material in a binder is placed in a mold having the required shape, such as a toroid. The material is pressed in the mold to form a core of the desired density. Thereafter, the core is sintered to cause the particles to adhere to each other. The molds are expensive, and because of the abrasive nature of the ferrite material, they wear out rather rapidly. Also, because of differences in the filling and pressures from mold to mold, there are marked differences in core sizes and densities, thus resulting in a nonuniform product. A uniform product is most essential in the present day construction employed for magnetic-core memories. A method for producing magnetic cores having uniform dimensions and properties would simplify the requirements for memory drive circuits. Also, it is most desirable to find a way to manufacture such cores which eliminates the need for expensive molds, without itself being expensive.

OBJECTS AND SUMMARY OF THE INVENTION

One object of the present invention is to provide a method and apparatus for producing magnetic cores at a lower cost.

Another object of the invention is to produce magnetic cores having more uniform and predictable properties than heretofore.

The present invention provides a method and means for the production of magnetic cores by punching them from sheets of material containing particles of magnetic material in a nonbrittle binder. The cores are formed with a minimum of handling by punching a disc of material from the sheet and punching a hole in the center of the disc (in the case of toroidal cores) at the same time. The magnetic cores so formed are collected and then placed in an oven for heating to remove the binder and to provide sintering.

In one embodiment of the invention, for producing toroidal cores, the sheet of material is formed as an elongated strip in which the magnetic particles have been mechanically imbedded in a plastic binder which is easily sheared. The strip is passed into a forming machine comprising a roller which intermittently advances the strip. The forming machine includes a first die having a round hole with a diameter substantially equal to the outer diameter of the core prior to heat treating. A second die having a ring shape is positioned opposite the first die for moving therein. A third die is also provided which is positioned opposite the second die, to move into the hole in the ring-shaped second die.

To form the magnetic core, the first die is positioned on one side of the strip of material, and the second die is positioned on the other side. The second die is pushed through the material and through the first die to form a disc of magnetic core material. At the same time, the third die is pushed through the disc into the second die to form the hole in the disc. The third die is immediately withdrawn so that the formed magnetic core rests on top of the second die, which projects completely through the first die. A jet of air blows the toroidal core off the second die into a collecting chute. When a large number of magnetic cores has been collected, they are taken to an oven for removing the binder and for sintering.

The magnetic cores undergo a small and known amount of shrinkage in the heat-treating processes, and this factor is taken into account in dimensioning the dies. This amount of shrinkage is about the same as is presently experienced with the mold manufacturing techniques.

Due to the nature of the binding material, relatively small punching pressures are required to cut the cores from the sheet. Furthermore, the punch diameters of magnetic cores are very small, so that only small areas must be punched out of the sheet. Accordingly, a gang of die sets is employed to form many cores at once, and the actuation of the dies as well as movement of material through the apparatus is performed by cams located on a single camshaft.

The novel features of the invention are set forth with particularity in the appended claims. The invention will best be understood from the following description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a representation of a process for forming a sheet of magnetic core material in accordance with the invention;

FIG. 2 is a simplified sectional view of an apparatus for forming magnetic cores from a sheet of magnetic core material, shown prior to forming;

FIG. 3 is a view of the apparatus of FIG. 2 shown during the forming of a magnetic core;

FIG. 4 is a sectional view taken on the line 4-4 of FIG. 3, showing the ejection of a magnetic core formed by the apparatus;

FIG. 5 is a partial plan view of a striplike sheet of core material, out of which groups of magnetic cores have been punched;

FIG. 6 is a perspective view of a magnetic core, formed in accordance with the invention;

FIG. 7 is a sectional elevation view of forming apparatus constructed in accordance with the invention;

FIG. 8 is a plan view of the apparatus of FIG. 7; and

FIG. 9 is a sectional elevation view of another embodiment of a forming apparatus constructed in accordance with the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIGS. 1 through 4 show the steps involved in the formation of magnetic cores in accordance with the invention, and FIG. 6 illustrates the configuration of a typical magnetic core end product. The first step in the formation of cores is the mixing of particles of magnetic ferrite material with a binder. The mixture is applied to heated rolls 10 and 12 as illustrated in FIG. 1, as by dropping a quantity 14 of the mixture on one of the rolls. The rolls form a sheet of suitable thickness as shown at 16, by successive passes through the rolls.

The sheet of material, which may be in strip form, is then passed through a forming apparatus, shown at 18 in FIGS. 2 through 4, which punches toroidal magnetic cores out of the sheet. The sheet 16 is advanced into the punching apparatus by material advancing rolls, including a driven roll 20 and an idler roll 22. The apparatus includes a first die 24, second die 28, and third die 30, which form cores from the sheet.

The sheet of material is advanced between the first die 24, which is disposed along the path of the strip on one side thereof, and the second die 28, which is disposed on the other side of the path. The first die has a hole 26 with a diameter equal to the outer diameter of the magnetic core to be punched. The second die 28 has a ring-shaped cross section with an outer diameter approximately equal to the diameter of the hole 26 of the first die for movement therein in punching out a magnetic core. The third die 30 is positioned on the same side of the path as the first die. The third die includes a rodlike portion having a diameter approximately equal to the diameter of the hole in the second die 28 for movement therein in punching out the central hole in the toroidal magnetic cores to be formed. Die holders 32 and 34, which hold the second and third dies, are advanced toward the path of the sheet 16 to cause the second and third dies to punch holes through the sheet.

FIG. 3 illustrates the punching step by which the magnetic cores are formed. Punching is performed by the movement of the second die 28 upwardly by its die holder 32 through the first die 24, to form a disc 36 of magnetic core material from the sheet 16. Simultaneously the third die 30 is moved down by its die holder 34 into the second die 28, to punch a central area or slug 38 out of the disc 36. During the entire punching
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operation, the rolls 20 and 22 remain stationary, and only until the second die 28 is withdrawn to its original position is the sheet from the rolls 20 and 22 displaced. The sheet results in the punching of discs out of it at regular intervals, leaving holes such as those shown at 40.

FIG. 4 shows the further step of removing the toroidal-shaped magnetic core from the punching apparatus. After the central slug 30 is punched out of the disc 36, the third die 30 is withdrawn to its uppermost position so that it is no longer within the second die. The second die 28 continues to move up and carry the core shown at 42 with it until the core is opposite the opening in a large receiving pipe 44. An air jet pipe 46, connected to an air supply, continuously blows a stream of air towards the receiving pipe 44. When the second die moves the magnetic core 42 opposite the receiving pipe 44, the air jet from the pipe 46 blows the core 42 into the receiving pipe which carries it to a container 48. The central slugs 38 drop through a tapered hole in the second die 28 and into a container 50 where they are collected for disposal. The sheet remnant left after discs have been punched out is mixed into new batches of material out of which new sheets are formed.

The magnetic cores collected in the container 48 are placed in a furnace where the binding material is removed and where sufficient heat is applied to cause sintering. The resulting magnetic cores, which are about 20 percent smaller than when they are first punched out of the sheet, are ready for use. The cores, as originally formed from the sheet, and as they appear after sintering, have the appearance of the core shown in FIG. 6. Formed other than toroids can be produced, by altering the shape of the die so that the hole in the first die has the form of the periphery of the desired core, the third die has the form and location corresponding to the aperture in the final core, and the second die is formed to mate with the first and third dies.

The process of formation of the sheet 16 containing particles held in a binder can be accomplished to provide a sheet having very high uniformity, so that the resulting cores have uniformly predictable properties. One method of forming such a sheet is by mixing into a wet slurry, a ferrite composition, such as one having the formula (in mol percent) 14.3 MgO, 3.7 ZnO, 40.8 MnO, 41.2 Fe3. The wet slurry can be formed by mixing the basic metal oxides with distilled water, placing the mixture in a ball mill and operating the ball mill for an adequate time period to assure thorough mixing. The wet mixture of basic metal oxide is then heated in air to remove the moisture. The dried powder mixture is thereafter sifted with a 20 to 30 mesh screen.

The sifted powder mixture of basic metal oxides is then placed in saggers, which are covered and stacked in a furnace for heating. The heating process is known as calcining, and its purpose is to react the ferrite oxide with the metal oxides, such as two of the following: magnesium, manganese, zinc. The calcined ferrite is then formed as a wet slurry by adding a small amount of distilled water or alcohol. The mixture is ground in a ball mill in order to reduce the particle size to about 3 to 5 microns, after which the material is again dried and sifted.

The ground ferrite mixture is then combined with a binder, such as an organic wax in a ratio such as 87 percent powder and 13 percent wax by weight. The wax binder is mixed with the powder on a rubber mill comprising a pair of rollers which are driven in opposite directions but at slightly different speeds. This produces a shearing action on the material, which thoroughly mixes the binders with the particles, and this mixing continues until a sheet is formed. After a sheet is formed, the roll separation is reduced until a sheet of desired dimensions is produced. This sheet of material is now ready for passing through the punching apparatus to form the magnetic cores.

In the way that 7 and 8 illustrate a punching apparatus for forming eight magnetic cores at a time from a strip of ferrite material, such as the strip shown in FIG. 5. The portion of the strip of FIG. 5 which has holes 40 is the remnant left after the punching of magnetic cores therefrom. The apparatus comprises a housing 62 including a base 60. The housing has slots 64 and 66 through which a strip of ferrite material passes, the strip moving along a path that brings it between dies that perform the punching operations.

Material entering the slot 64 is advanced by a driven roller 68 and an idler roller 70. The driven roller 68 is mounted on a material advancing shaft 72 which is rotated after each group of cores has been punched from a sheet, to advance the material into the punching mechanism. A lower table 74 and upper table 76 are mounted on the base 60 by supports (not shown). The upper table 76 supports a first die 78 having eight round apertures 80, each aperture having a diameter equal to the outer diameter of the toroidal magnetic cores to be formed (before subsequent heat treating of the cores). An opposing plate 82 is positioned on a side of the ferrite sheet opposite the first die. A second die 84 having eight ring-shaped punching portions is positioned on a side of the material path opposite the first die 78. Each of the ring-shaped portions of the second die 84 has an outer diameter slightly smaller than the aperture 80 in the first die, to provide the required clearance to allow its passage therethrough. The center hole in each ring-shaped portion is equal to the diameter of the central hole of a magnetic core to be formed.

The punching apparatus also includes a third die 88 positioned on the same side of the material path as the first die 78. The third die 88 includes eight coring portions or pins, each having an outer diameter slightly smaller than the hole 87 in each ring-shaped portion of the second die, to provide clearance for movement through the apparatus.

The punching of magnetic cores from a sheet of material is accomplished by positioning the sheet between the lower and upper tables 74 and 76. The second die 84 is moved into the apertures 80 in the first die to punch out plates of material having the form of discs. At the same time, the third die 88 is moved into the holes 86 in the second die to punch out the central areas of the discs, thereby forming toroidal cores. The opposing plate 82 serves to align the second die 84 with the apertures 80 in the first die.

Movements of the second and third dies and the driven roller 68 must be synchronized for proper forming of the magnetic cores. The force required to punch out material is usually high. However, in this case, only relatively small punching forces are required, because the binding material of the ferrite sheet is relatively weak. This permits the use of a relatively small cam system to supply forces to operate the second and third dies and advance the material advancing roller, thereby synchronizing these operations with relatively simple apparatus.

The second die 84 is held in a second dieholder 90 which engages flanges 92 on the second die. A return yoke 94 holds the second dieholder 90 with sufficient force to pull the second die back down after punching of the core has been completed. The force for pushing the second die up and bringing it back is supplied by a second arm, which functions as an operating means to move the die 84 into the first die and withdraw it therefrom. The arm 96 is, in turn, fixed to a second die arm shaft 98. The shaft 98 is pivoted back and forth to rotate the punch arm 96. When the shaft 98 is pivoted to push the second die 84 upwardly, force is transmitted through a rocker arm 100 to the second die holder 90 to push the second die up. Return of the second die is accomplished by pulling down on the return yoke 94.

In a similar manner, the third die 88 has flanges 102 held in a third dieholder 104. The third dieholder 104 is, in turn, held by a return assembly comprising a guide 106 and a yoke 107. The second dieholder 104, guide 106 and a yoke 107. The second dieholder 104, guide 106 and return yoke 107 are moved down by forces applied through an upper rod arm 110, which serves as an operating means to move the third die 88 toward and away from the second die. Downward forces are applied through a rocker arm 112. The upper rod arm 110 is fixed to a third die drive shaft 112, which is moved by a cam.
The three shafts 72, 98, and 112, which govern movements of the material through the apparatus and movements of the second and third dies, are each pivoted by a cam arrangement. FIG. 8 shows a portion of the punching apparatus which contains the cams that rotate the shafts. A camshaft 116 has an end 118 adapted for connection to a motor that rotates it. The camshaft 116 has three cams 120, 122, and 124 mounted thereon, which transmit the power that moves the material and dies.

The first cam 120 is used for transmitting power to rotate roller 68, which advances material into the apparatus, thus providing a cam operated moving means for advancing a sheet into the forming apparatus. The cam 120 moves one end of a pawl 126 up and down. The pawl is pivoted on a shaft 128 and its other end 130 advances ratchet wheel 132, which is fixed to the drive shaft 72. At each revolution of the camshaft 116, the shaft 72 rotates by an increment, and the drive roller 68 advances a strip of material further into the apparatus.

The cam 124 on the camshaft transmits power that moves the second die 84 up and down. Cam 124 pivots an arm 134 which is fixed to the shaft 98 that moves the second dieholder. A roller 136 is pivotally attached to the arm 134 to facilitate the application of force from the cam 124 to the arm 134. At each revolution of the camshaft 116, the arm 134 is raised, thereby rotating the shaft 98 and raising the second die punch arm 96. This results in upward movement of the second die to punch discs out of the sheet of ferrite material.

The cam 122 on the camshaft 116 transmits the power required to move the third die 88 up and down. The cam 122 moves an arm 138, through its action on an intermediate roller 140 attached to the arm. This causes pivoting of the shaft 112, which moves the third die. At every rotation of the camshaft 116, the shaft 112 is pivoted to cause the second upper rod arm 90 to move the third die downwardly and punch out the central area of the magnetic cores. The use of the cam driven shafts to move the second and third dies provides a relatively simple reciprocating means for synchronizing the reciprocating movements of the dies.

FIG. 8 illustrates the form of the first die 78, showing the eight laterally-spaced apertures 80 therein, which enable the simultaneous punching out of eight magnetic cores. The second die may be constructed by utilizing a single element having eight ring-shaped die portions formed therein as the punch portion, or by utilizing eight separate punches with the eight separate punches held by one elongated second dieholder 90. Similarly, the third punch 88 may be formed by a continuous flange section 102 having eight pinlike projections serving as the corresponding portions or magnetic pins. As shown in FIG. 7, the second and third dieholders have undercut slots 83 and 85, to hold the flanges of each of the eight cylindrically shaped dies. The second dies 84 are hollow cylinders, while the third dies 88 are solid cylinders or pins.

The forming actions performed by the apparatus of FIGS. 7 and 8 are similar to those shown in FIGS. 2, 3, and 4. The second and third dies are moved together so that the central hole in each magnetic core is punched out immediately after the disc of materials is punched out of the sheet. After the third die has punched the central area and has then moved upwardly, the resulting magnetic core is removed by blowing it off of the second die. An air jet pipe indicated at 142 is connected to a supply of air, for blowing air through each of its eight openings 144 at the formed magnetic cores. The formed cores are blown into the receiving pipe 146, which carries them to a collecting area 148.

Many variations in the apparatus and its manner of operation may be employed. For example, the lower and upper tables 74 and 76 may be moved toward each other prior to movement of the second and third punches through their opposed apertures, to more securely grasp the ferrite sheet. However, this is often not necessary for very easily formed materials, such as the plastic binder used in the ferrite sheet described above.

FIG. 9 illustrates another embodiment of the invention which provides a different method for removing the slugs 179 punched out of the center of the discs to form magnetic cores. In this FIG., the second die is located above the path of the sheet of core material, while the first and third dies are below it. Removal of slugs is accomplished with a fourth die 150 which ejects the slugs within the hollow second die 152, and another air jet 154 which blows the slugs 179 into a receiving conduit 156. FIG. 9 also shows another method for moving a strip of magnetic core material through the punching apparatus, comprising a pair of clamps 158 which hold the strip, the clamps being moved by a rack and pinion mechanism.

The apparatus of FIG. 9 is similar to that of FIG. 7, but the dies are essentially "upside down," i.e., the first and third dies 160 and 162 are below the path taken by the strip of material, while the second die 152 is above the path. The third die 160 is reciprocated by a third die rod arm 164 which moves a guide 166 and return yoke 168 toward and away from the second die 152. The second die is reciprocated by a second die rod arm 170 which moves a second dieholder 172 and return yoke 174 toward and away from the first die 160. The fourth die 150 is a long rod attached to a support 176 which is fixed to the housing 177 enclosing the apparatus. The air pipe 154 blows air across the end of the second die 152 and toward the slug receiving pipe 158 to move slugs into the receiving pipe.

The punching of magnetic cores from a strip of material is accomplished by moving the second die 152 into the first die 160 to form a disc of magnetic material. Additionally, the third die 162 is moved into the hollow portion of the second die to punch a slug out of the disc to form a toroid. The toroid initially lies below the first die 160 and can be blown into a toroid receiving pipe (not shown) by an air jet while the second die 150 is projecting through the first die 160 in a manner similar to that shown in FIG. 4. The slug 179 formed by the third die 162 is held in the hollow portion 178 of the second die 152. As the second die 152 is moved upwardly to withdraw it from the first die, it carries the slug. Toward the end of the upward motion of the second die, the fourth die 150 pushes the slug out of the second die, by preventing its upward movement with the second die. The slug, shown at 179, ejected from the second die 152, is blown by a jet of air from the air pipe 154 into the slug receiving pipe 156. The slugs move through the receiving pipe into a collecting container 180.

The use of the fourth die to kick out the slugs is advantageous in that it enables the use of a second die 150 with a straight hollow cylindrical portion, instead of a tapered hollow portion. A die with a tapered hollow portion is difficult to make, and it has been found to sometimes jam unless the taper is carefully constructed to allow the slugs to pass therethrough.

In the apparatus of FIG. 9, the sheet of magnetic material is held between the pair of clamps 158 which move horizontally along guides (not shown). A rack 182 attached to one of the clamps is moved along by a pinion 184. The pinion is rotated intermittently in the same manner as the drive roller 68 of FIG. 7. Pinion rotation occurs when the second die 150 is withdrawn from the path of the sheet of magnetic material. If it is desired to move a long sheet into the apparatus, means can be included to release the clamps from the sheet, move the clamps and pinion to the left, and again clamp the sheet.

Although particular embodiments of the invention have been described and illustrated herein, it is recognized that modifications and variations may readily occur to those skilled in the art and, consequently, it is intended that the claims be interpreted to cover such modifications and equivalents.

I claim:

1. Apparatus for forming magnetic cores having a desired periphery and having at least one hole comprising:
   means defining a path for movement of a sheet of magnetic core material;
   first die means disposed along said path on a first side thereof, said die means having a hole for defining said desired periphery of a magnetic core;
second die means disposed along said path on a second side thereof opposite said first die means, said second die means including a punch portion for slidably insertion into said hole in said first die means, said punch portion having a hole formed therein for defining a hole in a magnetic core;
third die means disposed on the same side of said path as said first die means and positioned opposite said second die means, said third die means having a coring portion for movement into said hole in said second die means; first operating means for moving said second die means into said first die means and for withdrawing said third die means from said second die means; and
moving means for periodically advancing said sheet of magnetic core material a uniform interval along said path after said second die means is withdrawn from said first die means.

2. Apparatus for forming magnetic cores as defined in claim 1 wherein said moving means comprises material engaging means having a portion adjacent to said path for engaging a sheet of material and moving it along said path; and including:
housing means;
an advancing shaft mounted on said housing means;
means for coupling said material engaging means to said advancing shaft;
ratchet wheel means fixed to said advancing shaft;
camshaft means mounted on said housing means;
motor means for rotatively driving said camshaft means;
material advancing cam means mounted on said camshaft means; and
pawl means connecting said material advancing cam means and said ratchet wheel means for incrementally rotating said ratchet wheel means, whereby said sheet of magnetic core material is advanced in uniform intervals.

3. Apparatus for forming magnetic cores as defined in claim 1 including:
housing means;
camshaft means mounted on said housing means;
motor means for rotatively driving said camshaft means;
first cam follower means coupling said first cam means to said first operating means;
second cam follower means coupling said second cam means to said second operating means, for operating said second operating means substantially simultaneously with the operation of said first operating means; and
means coupling said third cam means and said moving means, for incrementally operating said moving means in synchronism with the operation of said first and second operating means, whereby said sheet of magnetic core material is advanced a uniform interval.

4. Apparatus for forming magnetic cores as defined in claim 1 including air jet means disposed on a side of said first die means which is opposite to said path, said jet means having an air outlet directed substantially across the end of the path of travel of said second die means into said first die means, for removing magnetic cores carried through said first die means by said second die means.

5. Apparatus for forming magnetic cores as defined in claim 1 including fourth die means having a rod portion with an end for projection through said hole in said punch portion of said second die means to eject slugs from said hole.

6. Apparatus for forming toroidal magnetic cores from a sheet of magnetic core material comprising:
means defining a path for movement of said sheet;
a first die having a hole in it defining the outer diameter of said magnetic cores, said first die positioned on a first side of said path;
a second die having an end portion with the form of a hollow cylinder for insertion into said first die, said second die positioned on a second side of said path opposite said first die;
a third die for insertion into the hollow portion of said second die, positioned on said first side of said path; reciprocating means for reciprocally moving said second and third dies simultaneously toward each other and for moving said second and third dies away from each other; and
means for periodically advancing said sheet of magnetic core material a uniform interval along said path when said second and third dies are positioned away from each other and after said second die is withdrawn from said first die.

7. Apparatus for forming magnetic cores as defined in claim 6 including ejecting means within said hollow cylindrical end portion of said second die for movement relative to said end portion along its axis to eject slugs therefrom.

8. Apparatus for forming magnetic cores as defined in claim 7 wherein said ejecting means comprises a rod positioned within the hollow portion at the end of said second die, said rod having an end projecting substantially past said second die when said second die is in a position furthest from said path of said sheet, whereby to automatically eject slugs from said second die when it is moved to its extreme position away from said sheet.

9. Apparatus for forming magnetic cores as defined in claim 6 wherein said reciprocating means comprises:
camshaft means for holding cam means;
motor means for rotatably driving said camshaft means;
first cam means mounted on said camshaft means for operating said second die;
means coupling said first cam means to said second die for moving it toward and away from said third die;
second cam means mounted on said camshaft means for operating said third die; and
means coupling said second cam means to said third die for moving it toward and away from said second die, whereby said second and third dies are moved synchronously with respect to each other.

10. Apparatus for forming toroidal magnetic cores from a sheet of magnetic core material comprising:
housing means defining a path for movement of said sheet therealong;
first die means positioned along said path on a first side thereof, having a plurality of spaced circular holes, each hole defining the outer diameter of a magnetic core; second die holding means for holding a plurality of second dies, said second die holding means positioned on a second side of said path opposite said first die means;
a plurality of second dies mounted on said second die holding means, each of said second dies having a hollow substantially cylindrical portion aligned with a hole in said first die means for movement therein to punch a disc of material from said sheet;
third dieholder means positioned on said first side of said path for holding a plurality of third dies; a plurality of third dies mounted on said third dieholder means, each of said third dies having a substantially cylindrical coring portion for movement into the hole in one of said second dies to punch a core from a disc formed by said second die;
first reciprocating means for reciprocally moving said second die holding means toward and away from said first die means to alternately insert and withdraw said second dies into and from said first dies;
second reciprocating means synchronized with said first reciprocating means, for reciprocating said third dieholder means toward and away from said path to alternately insert and withdraw said third dies into and from said second dies; and
means synchronized with said first reciprocating means, for periodically advancing said sheet a uniform interval along said path after said second dieholder means is in a posi-
Apparatus for forming magnetic cores as defined in claim 10 wherein:

each of said third dies comprises a rod having a flange disposed within said undercut slot.

12. Apparatus for forming magnetic cores as defined in claim 10 including:

air jet means located on a side of said first die means opposite said path, and having an outlet means directed across the ends of the paths of said second dies for removing cores by air movement; and chute means having an opening facing said outlet means for collecting cores.

13. Apparatus for forming magnetic cores as defined in claim 10 wherein said second dies are normally positioned above said first die, to allow toroidal cores to drop off of said second dies while they are projecting through said first dies;

and including:
ejecting means for ejecting slugs in said second dies when said second dies are withdrawn from said first die means;

and means disposed on said second side of said path for collecting slugs ejected from said second dies.

14. Apparatus for forming magnetic cores as defined in claim 13 wherein said means for collecting slugs comprises:

slug receiving pipe means for receiving slugs and air pipe means for directing a jet of air across the end of said second dies and into said slug receiving pipe means.