May 17, 1966 A. F. MITTERMAIER 3,251,208

MACHINE AND METHOD FOR FORMING LAMINATIONS FOR MAGNETIC CORES

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Fig. 11.

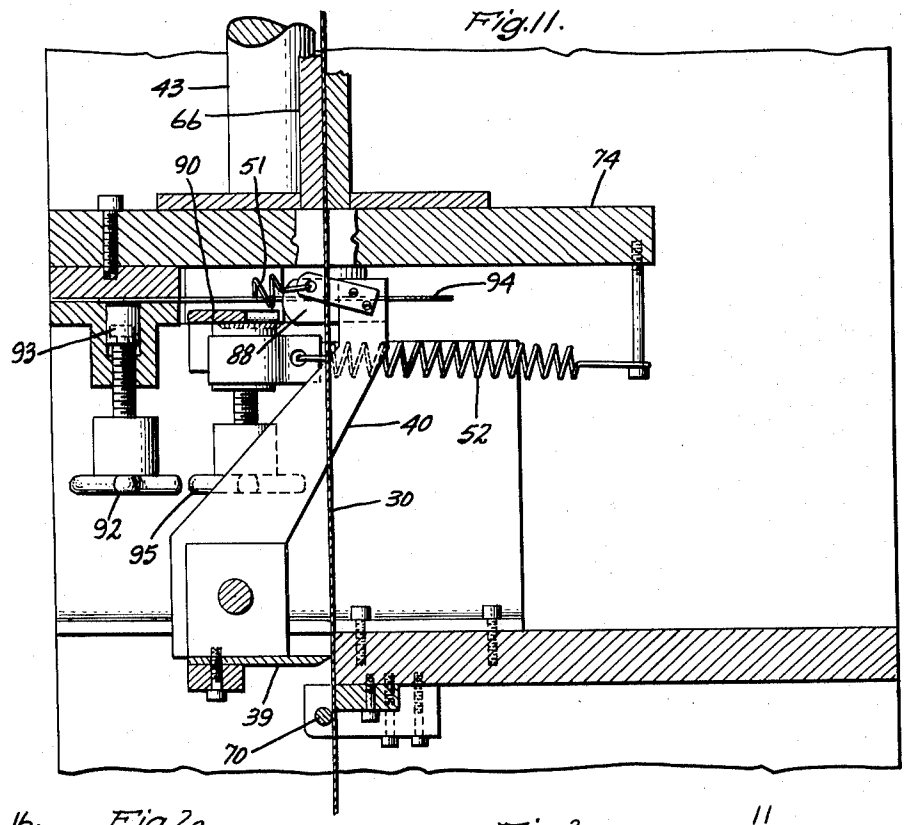


Fig. 2a.

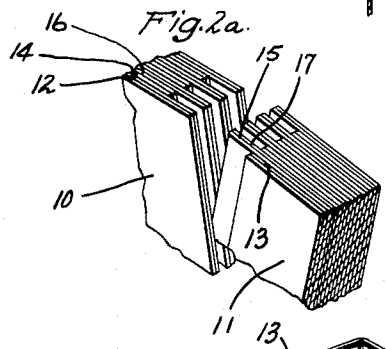
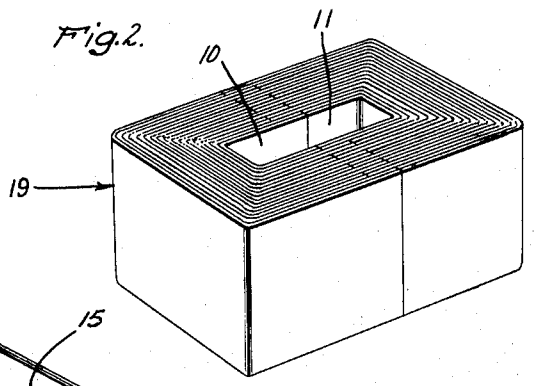


Fig. 2.



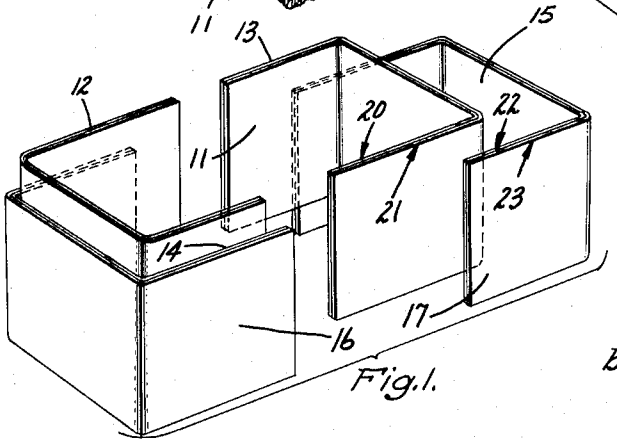


Fig. 1.

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MACHINE AND METHOD FOR FORMING LAMINATIONS FOR MAGNETIC CORES

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Fig. 3.

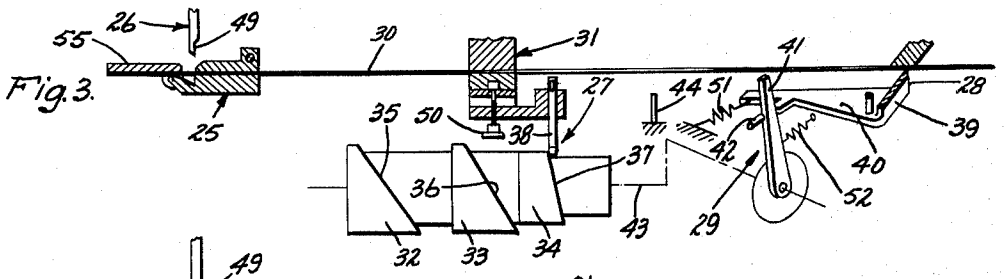


Fig. 4.

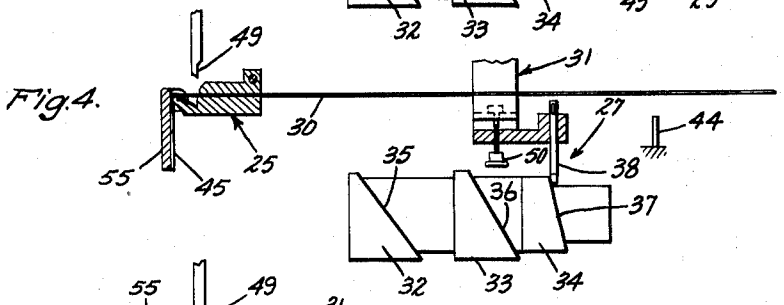


Fig. 5.

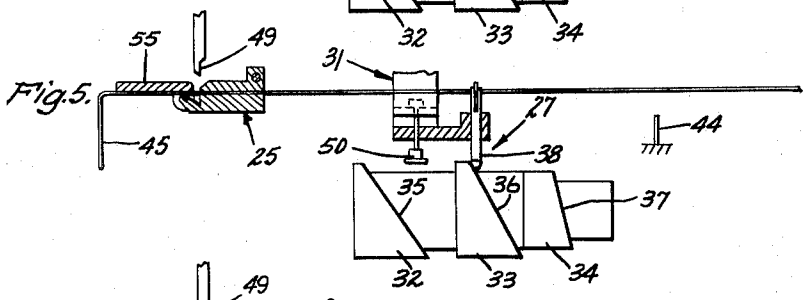


Fig. 6.

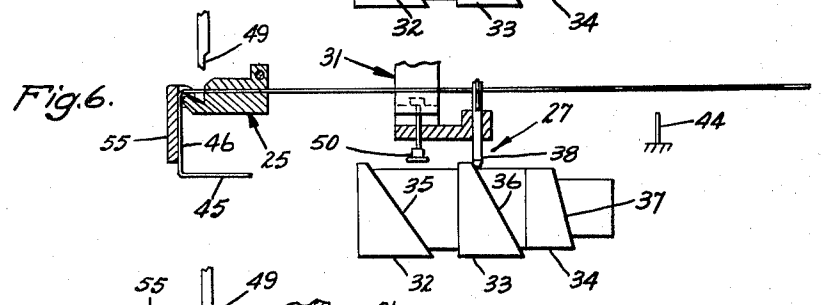


Fig. 7.

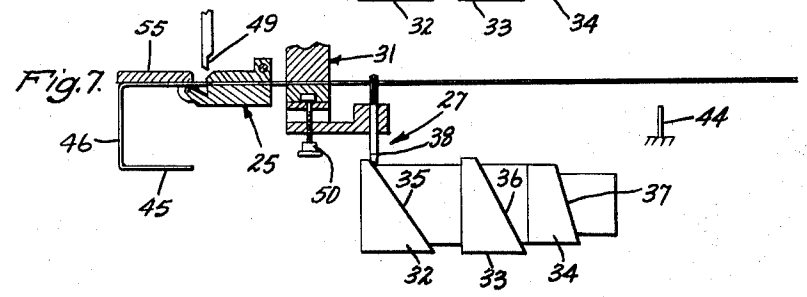
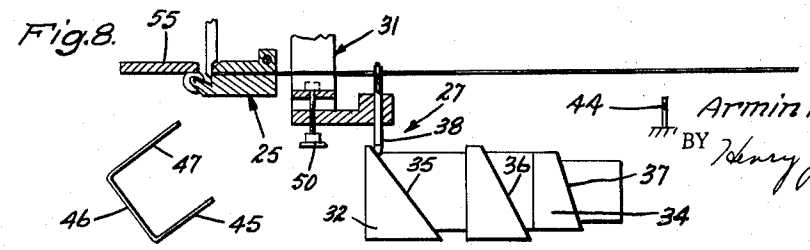


Fig. 8.



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MACHINE AND METHOD FOR FORMING LAMINATIONS FOR MAGNETIC CORES

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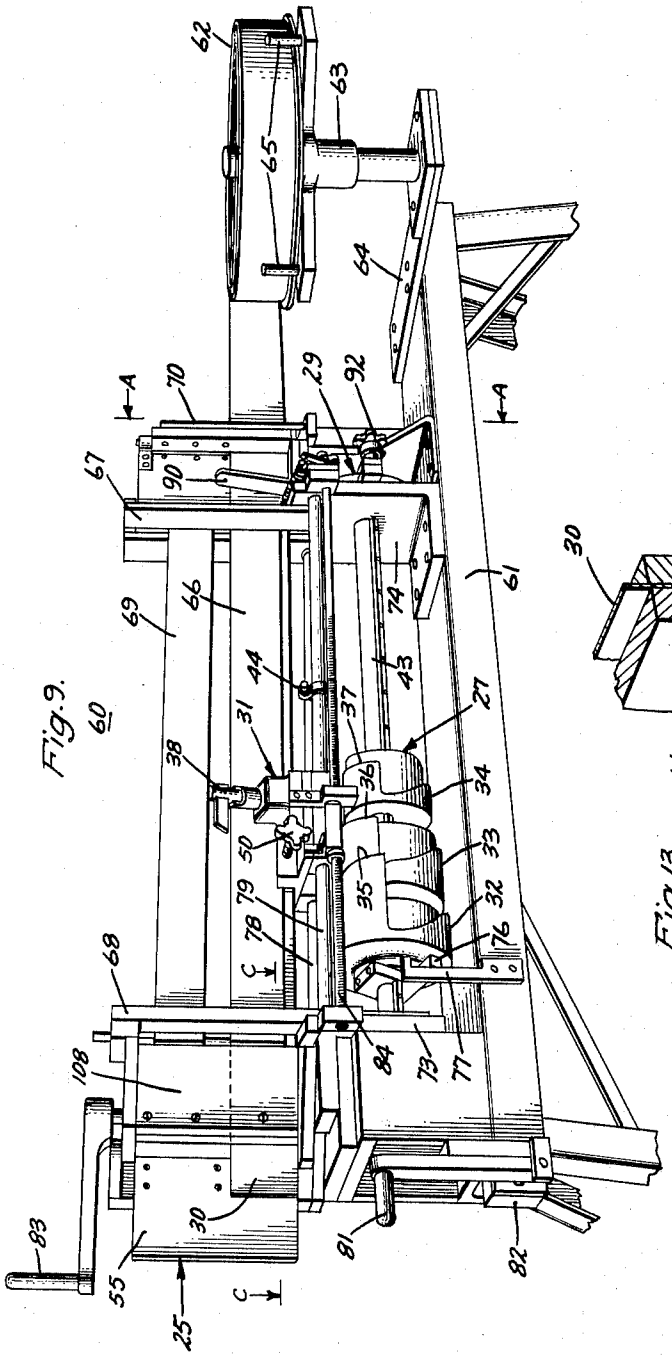


Fig. 9.

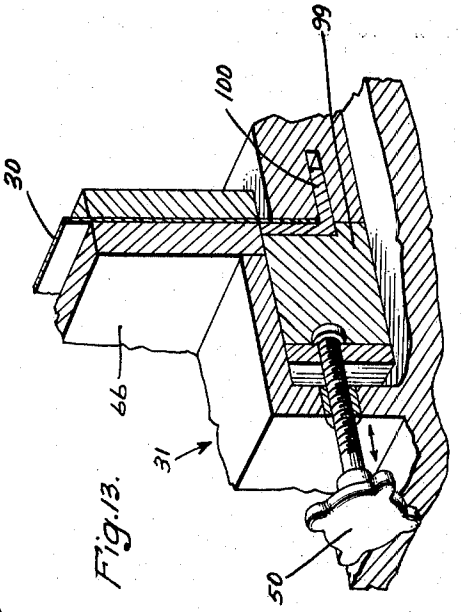


Fig. 13.

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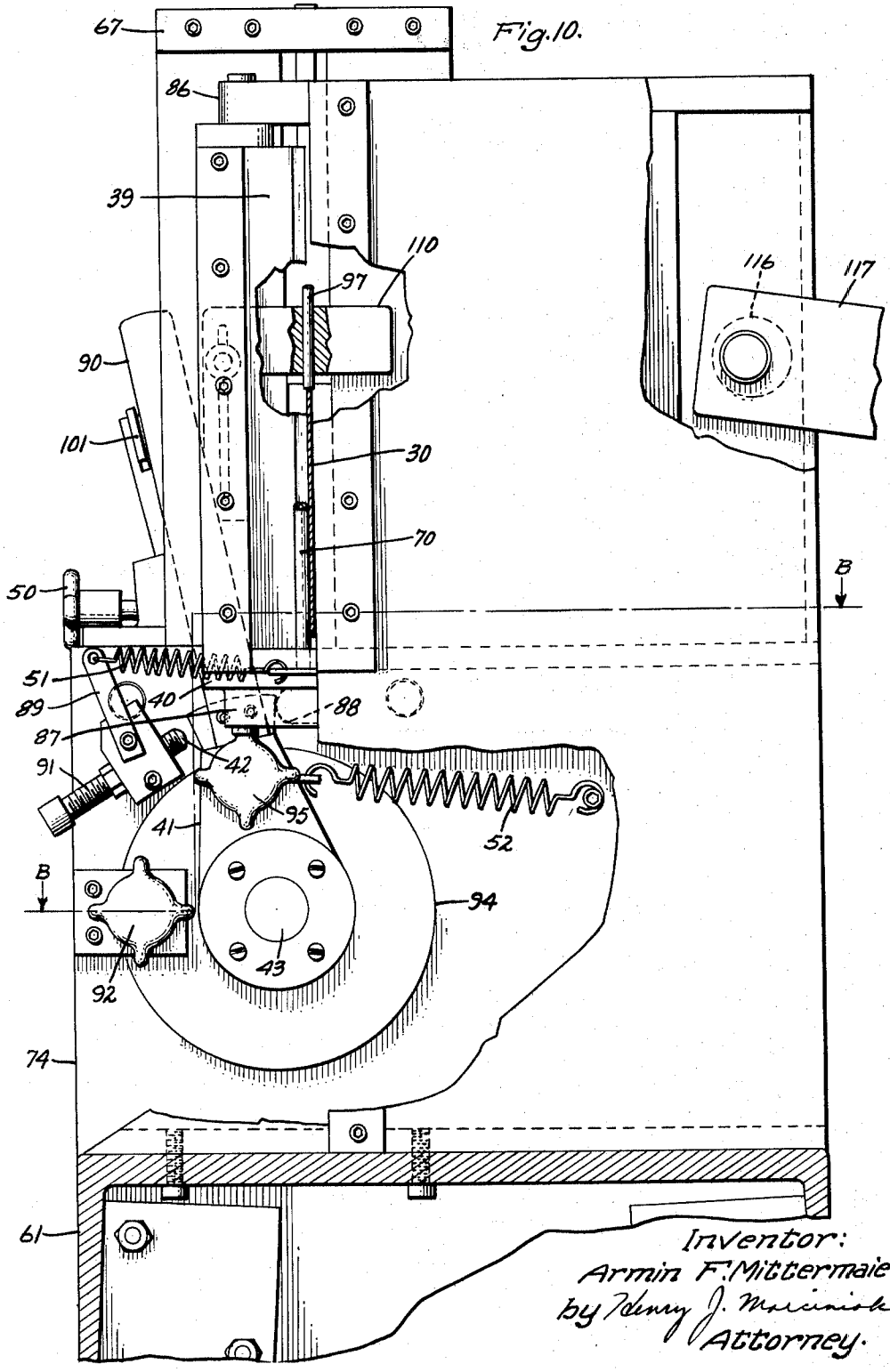
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May 17, 1966 A. F. MITTERMAIER 3,251,208

MACHINE AND METHOD FOR FORMING LAMINATIONS FOR MAGNETIC CORES

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Fig. 10.



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MACHINE AND METHOD FOR FORMING LAMINATIONS FOR MAGNETIC CORES

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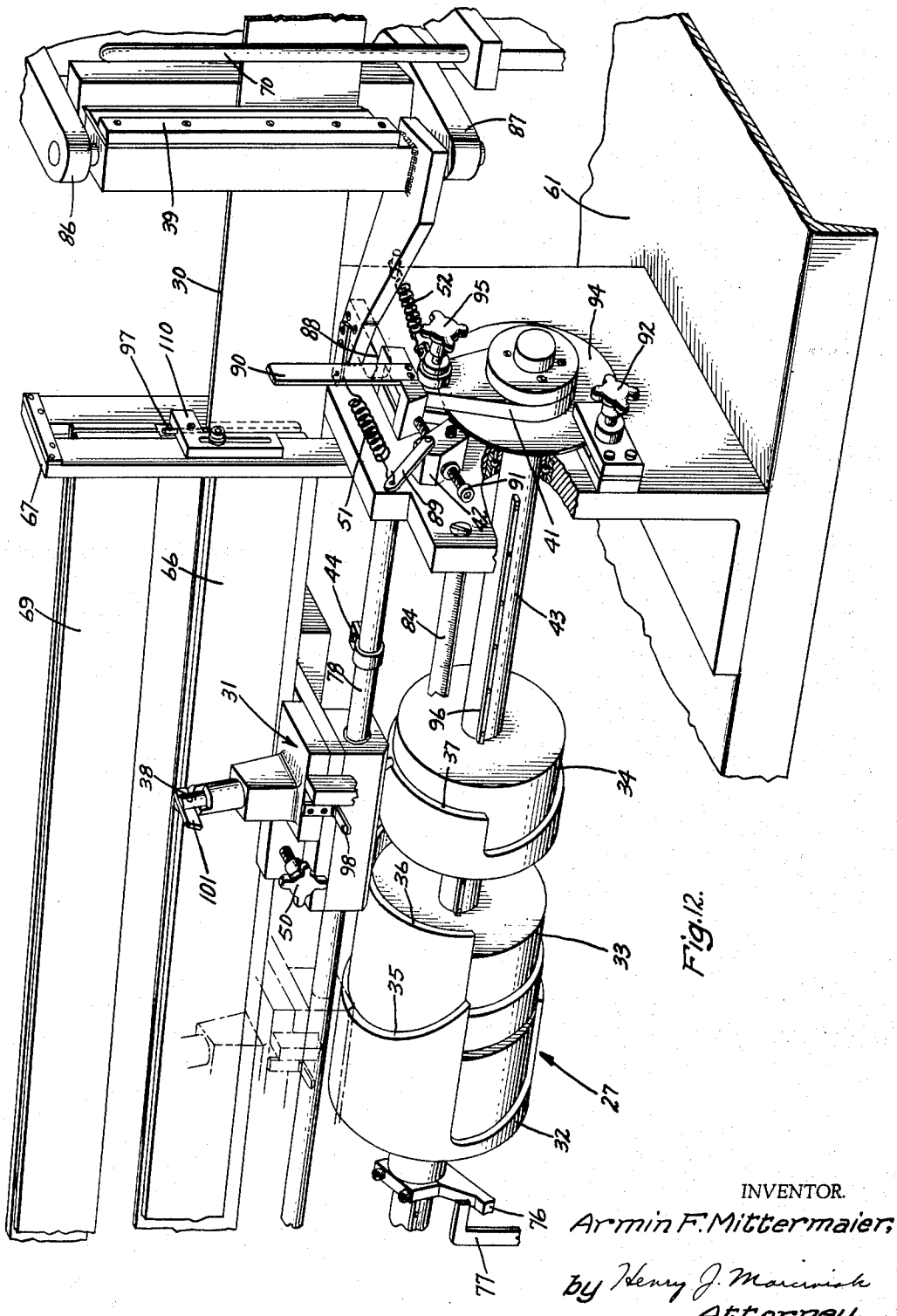


Fig. 12.

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MACHINE AND METHOD FOR FORMING LAMINATIONS FOR MAGNETIC CORES

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Fig. 14.

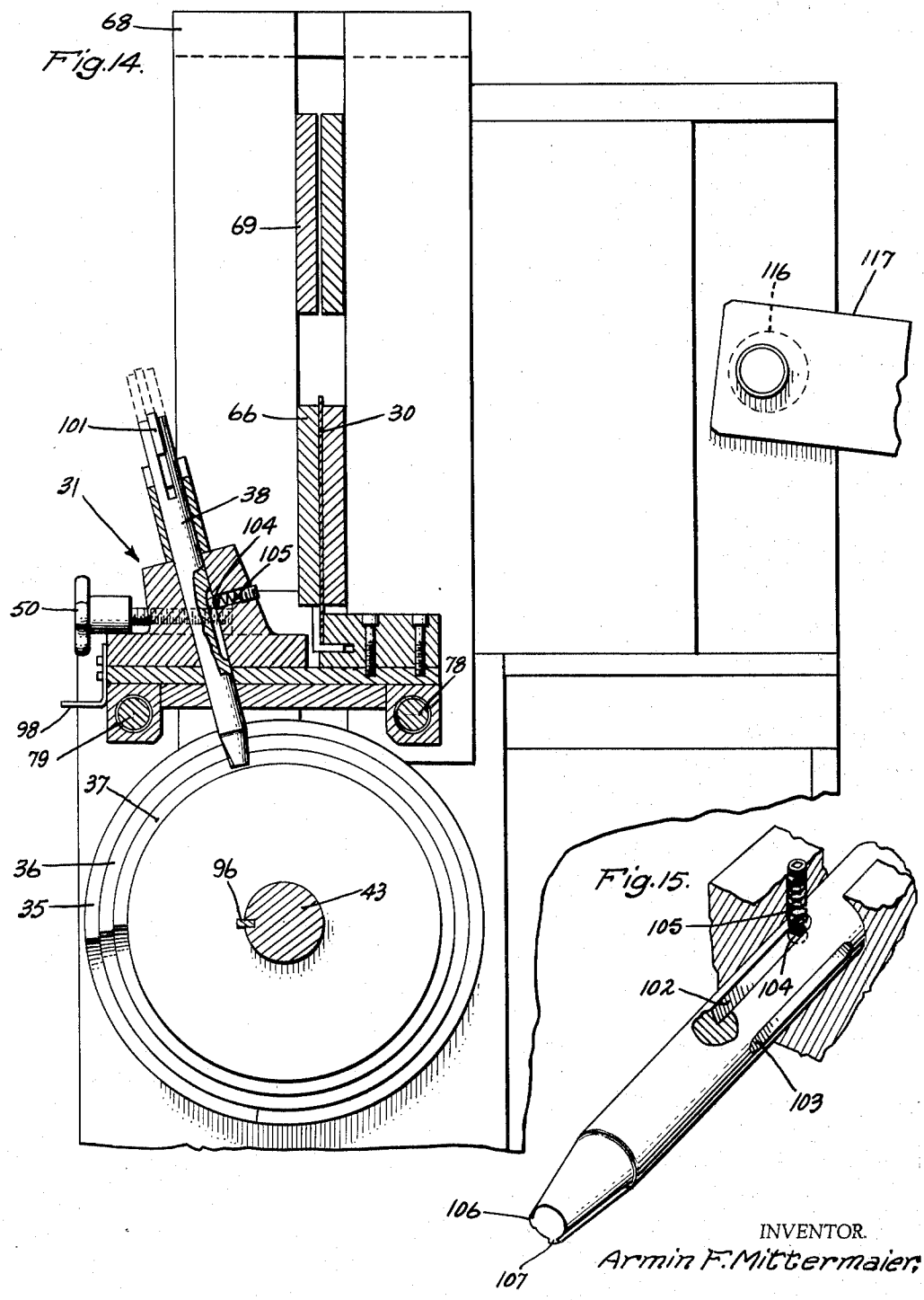


Fig. 15.

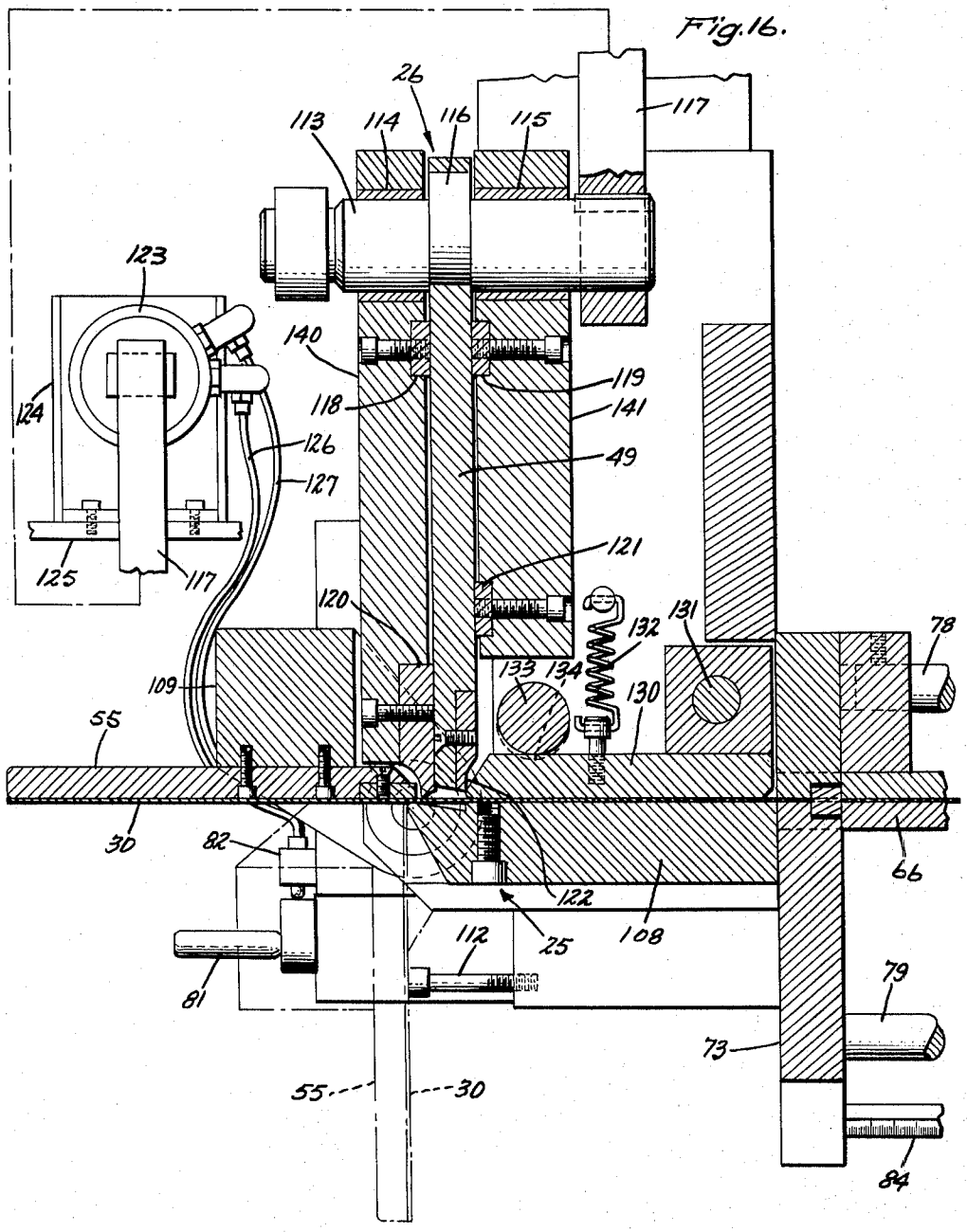
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MACHINE AND METHOD FOR FORMING LAMINATIONS FOR MAGNETIC CORES

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Fig. 16.



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United States Patent Office 3,251,208 Patented May 17, 1966

3,251,208

MACHINE AND METHOD FOR FORMING LAMINATIONS FOR MAGNETIC CORES

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Filed May 27, 1963, Ser. No. 283,299
10 Claims. (Cl. 72—16)

This invention relates to machines and methods for forming laminations for magnetic cores. More particularly, it relates to such machines and methods adapted for use in connection with magnetic cores comprised of laminations preformed of strip steel so that the flux path is essentially in the direction of rolling of the strip steel.

In a conventional shell type of core, such as is widely used in small power transformers, the core is made by stamping lamination punchings from strip steel and stacking the lamination punchings to form the core structure. In the transverse portions of the core structure, the flux traverses a path that is essentially at right angles to the direction in which the strip steel was rolled. Magnetic cores formed of magnetic material, such as cold rolled silicon strip steel, are characterized by lower exciting current and core losses when the flux path is in the direction of rolling. Thus, core structures made from lamination punchings do not best utilize the properties of the cold rolled strip steel.

In order to best utilize the directional characteristics of the magnetic strip steel, various methods have been proposed for forming the laminations of magnetic cores. A core may be formed by providing one or two generally U-shaped core members of curved or bent strips of magnetic material and joining the U-shaped member at the ends to form a closed magnetic circuit. Such U-shaped core members in the past have been formed by bending a stack of pre-cut strips of magnetic material on a mandrel to form a U-shaped configuration. Where two such U-shaped core members are to be joined to form a closed loop, heretofore difficulties have been encountered in joining the ends of U-shaped core members together as a unit. Further, in bending the stacks of pre-cut strips of magnetic material to form the desired U-shaped configuration the magnetic material is frequently bent beyond its elastic limit. Such bending, of course, destroys or has a detrimental effect on the magnetic properties of the steel. Methods of making magnetic cores by preforming laminations to predetermined sizes have also posed problems since the thickness of magnetic strip steel varies. Because of this variation in thickness, the dimensions of individual lamination sections which are to be preformed cannot be predetermined with any degree of accuracy.

There has been a long standing need for a machine and method for preforming laminations from a continuous strip of magnetic material. Further, it is extremely desirable that such a machine and method be readily adaptable to automated and semi-automated manufacturing techniques. It is also desirable when required that the laminations be assembled with a predetermined space factor and with staggered core joints in order to minimize the core joint losses.

Accordingly, it is a general object of the present invention to provide an improved method and machine for forming a magnetic core of an electromagnetic induction apparatus.

Another object of the invention is to provide an improved machine for making preformed laminations for a magnetic core wherein the directional properties of the strip steel used to form the laminations are more effectively utilized.

It is still a further object of the present invention to provide an improved method and machine for forming

U-shaped laminations of a magnetic core wherein variations in the thickness of the magnetic strip material used are compensated for in forming the individual laminations.

A more specific object of the present invention is to provide a method for making preformed laminations for a magnetic core that is readily adapted to automated and semi-automated manufacturing techniques.

It is still a further object of the invention to provide an improved method of forming magnetic cores having generally U-shaped laminations in which the joints in the legs can be readily assembled and disassembled to mount one or more coil assemblies thereon.

In accordance with one form of my invention, I have provided an improved machine for making lamination sections from strip material for preformed magnetic cores comprised of lamination layers, each layer being formed of a pair of essentially U-shaped lamination sections. The improved machine for making lamination sections for such preformed magnetic cores includes a strip length indexing means for indexing a first, second and third length of strip material to form the first leg portion, the cross member and second leg portion, respectively, of a U-shaped lamination section. Further, in accordance with the present invention I have provided a means for adjustably varying the indexed lengths by increments proportional to the thickness of the strip material as determined by a strip thickness gauging means thereby to provide the indexed lengths for a lamination section of a succeeding lamination layer. The first and third lengths of the lamination section of a succeeding layer differ from the first and third lengths of the lamination sections of a preceding lamination layer by an increment equal essentially to one thickness and the space factor, if included. The second indexed length or the length of the cross member of the U-shaped lamination section of the succeeding layer differs from the second indexed length of the preceding lamination layer by essentially two increments.

The machine includes a forming means for bending the strip material to form the cross member and leg portions of the lamination sections and a means for shearing the strip material at the third indexed length to cut off the U-shaped lamination section from the strip material. Preferably, in the improved machine the indexing means is provided with a cylindrical cam arrangement having first, second and third cam surfaces for indexing the first, second and third lengths of the lamination sections. The cam surfaces are adjustably rotatable to change the first and third indexed lengths of a lamination section by one increment and to change the second indexed length by essentially twice the increment. Thus, in the improved machine the lamination sections formed for a succeeding layer are varied by increments proportional to the actual thickness of the strip material. An important advantage of this arrangement is that the dimensions of the individual lamination sections are proportionally adjusted as the thickness of the strip material varies thereby making it possible to readily fabricate the lamination sections for preformed cores, irrespective of variations in the thickness of the strip material.

According to another aspect of the invention I have provided an improved method for making the lamination sections of a preformed magnetic core. In carrying out the method of the invention, the lamination sections for an initial lamination layer are formed to provide substantially U-shaped lamination sections having a first and a second leg portion bent at substantially right angles with a cross member. The actual thickness of the strip material is determined before the succeeding lamination layer is formed, and the lamination sections for the succeeding layer are formed with leg portions having lengths that

vary from the lengths of the leg portions of the lamination sections of the preceding layer by essentially one increment proportional to the actual thickness. The cross member of the lamination section for the succeeding section is formed with a length that varies from the length of the cross member of the lamination sections of the preceding layer by essentially two increments.

The subject matter which I regard as my invention is set forth in the appended claims. The invention itself, however, together with further objects and advantages thereof may be better understood by the following description taken in conjunction with the accompanying drawings in which:

FIGURE 1 is a perspective view illustrating how a group of lamination sections formed in accordance with the improved method and machine of the invention are assembled;

FIGURE 2 is a perspective view of a preformed magnetic core formed of the lamination sections fabricated in accordance with one form of the invention;

FIGURE 2*a* is a fragmentary view of the joint of the core shown in FIGURE 2 and partially disassembled to show one of the joining laminations;

FIGURE 3 is a diagrammatic sketch of the principal elements of the improved machine shown in simplified form illustrating how the first length of the first leg portion of a lamination section is indexed;

FIGURE 4 is a view corresponding to the one shown in FIGURE 3 illustrating how the forming operation is carried out to form the first leg portion of a lamination section;

FIGURE 5 is another view corresponding to the view shown in FIGURE 3 wherein the second length or the length of the cross member of a U-shaped lamination section is indexed in accordance with the invention;

FIGURE 6 is another view corresponding to one shown in FIGURE 3 wherein a second forming operation is carried out to form the cross member of the U-shaped lamination;

FIGURE 7 is still another view corresponding to the view shown in FIGURE 3 in which the third length or the length of the second leg portion of a lamination section is indexed in accordance with the invention;

FIGURE 8 is a view corresponding to the one shown in FIGURE 3 wherein the lamination section formed in accordance with the invention is cut off from the strip material;

FIGURE 9 is a perspective view showing the overall arrangement of a machine embodying one form of my invention;

FIGURE 10 is a sectional view taken along line A—A of the view shown in FIGURE 9 with portions of the frame member broken away to illustrate the operating parts thereof;

FIGURE 11 is a view taken along the section line B—B as shown in FIGURE 10 to illustrate the strip gauging member arrangement;

FIGURE 12 is a perspective view of one end of the machine shown in FIGURE 9 and illustrating the strip length indexing assembly, the thickness compensating assembly and the strip gauging member;

FIGURE 13 is a fragmentary view partly in section of the strip material locking means;

FIGURE 14 is a sectionalized view of the indexing unit;

FIGURE 15 is a fragmentary view in perspective of the cam follower; and

FIGURE 16 is a sectional view taken along line C—C of FIGURE 9 illustrating the details of forming brake assembly and shearing mechanism used in the illustrative embodiment of the invention, the pneumatic system used to actuate the shearing blade being illustrated diagrammatically.

Referring now to FIGURES 1 and 2*a*, I have illustrated therein several preformed lamination sections **10**, **11**, **12**, **13**, **14**, **15**, **16** and **17** and in FIGURE 2 a magnetic core **19** made in accordance with the present invention. As will be seen in FIGURE 2 the magnetic core **19** is comprised of a plurality of essentially U-shaped lamination sections formed from strip material by indexing, bending and shearing operations to provide a core wherein the flux will traverse a path that is always in the direction of cold rolling. The magnetic core **19** is formed of two parts which are joined as shown in FIGURE 2*a*, to permit a coil or coils (not shown) to be assembled on the core **19**. In the illustrated embodiment of the invention the laminations were formed with long and short leg portions so that the joints between pairs of the lamination sections are staggered.

As is shown in FIGURE 1, a magnetic core of the type to which my invention relates is formed of lamination layers **20**, **21**, **22**, **23** each of the lamination layers including a pair of identical lamination sections. The innermost layer **20** includes the lamination sections **10**, **11**. The dimensions of the lamination sections **12**, **13**, which form the next or successive layer **21**, are increased so that they can be superposed on the lamination sections **10**, **11**. In order to stagger the butt joints between lamination sections, pairs of the lamination layers are alternately reversed. Although in the exemplification of the invention no air gaps were included in the core, if required, air gaps may be readily provided by shortening the lamination legs by a predetermined amount, as will be hereinafter more fully explained in connection with the detailed description of the machine used to form the lamination sections.

Having reference to the schematic diagrams in the FIGURES 3–8, which illustrate the sequence of operations performed, I will now more particularly describe how the indexing, forming and shearing operations are carried out. In the simplified form of the core making machine embodying the invention, as is shown diagrammatically in FIGURES 3–8, the machine generally comprises a forming brake assembly **25**, a shearing mechanism **26**, a strip length indexing assembly **27**, a strip thickness gauging member **28** and a thickness compensating assembly **29**. The strip material **30** is fed from a reel (not shown) located to the right of the thickness gauging member **28**.

The shearing mechanism **26** is represented schematically by a shearing blade **49**, and as will hereinafter be more fully described, the shearing blade **49** is pneumatically actuated to cut off the lamination section after the indexing and forming operations have been completed. The forming brake assembly **25** is actuated by switching a pivotally supported forming brake **55** through essentially a 90 degree angle to form a right angle bend in the strip material **30**. It will be appreciated that the forming brake **55** may be swung through an angle slightly greater than 90 degrees in order to form lamination leg portions that will, when assembled, more or less clamp together.

In general, the strip length indexing assembly **27**, as shown diagrammatically, includes a cam follower unit **31** and the cam cylinders **32**, **33**, **34** formed with cam surfaces **35**, **36** and **37**, respectively. The three lengths for a lamination section are indexed by moving a retractable follower **38** to a position of engagement against the cam surfaces **35**, **36** and **37**. It will be understood, of course, that the cam follower unit **31** is fixedly clamped against the strip material **30** so that when the unit **31** is moved to a position of engagement with one of the cam surfaces **35**, **36**, **37** the desired length of material is indexed and supplied to the forming brake assembly **25**.

The strip thickness gauging member **28** includes a blade **39** which can be brought into engagement with the strip material **30** to gauge the thickness. It will be seen that the blade **39** is carried on one end of a pivotally supported rocker arm **40**. The other end of the rocker arm **40** serves as a movable stop for the lever arm **41**. As the thickness of the strip material varies, the position

of the movable stop will be proportionally varied. The thickness compensating assembly 29 cooperates with the strip thickness gauging member 28 and the strip length indexing assembly 27 to impart an angular rotation to the cam cylinder 32, 33, 34. This angular rotation is proportional to the actual thickness of the strip material 30 as it is fed into the machine. Thus, the lever arm 41 of the thickness compensating assembly 29 when moved from its position of contact with the movable end of the rocker arm 40 to a position of contact with a fixed stop 42 will impart an angular displacement to the cam cylinders 32, 33, 34 that is proportional to the actual thickness of the strip material 30.

In the illustrated embodiment of the invention the strip gauging member 28 and the thickness compensating assembly 29 come into play only after a set of lamination sections for a given lamination layer are completed. When a lamination layer is completed, the lever arm 41 is engaged with the shaft 43 in order to impart the desired rotation to the cam cylinders 32, 33, 34. The cam surfaces 35, 36, 37 are designed to cause the first and second indexed lengths to be increased by one increment proportional to the actual thickness and to cause the second indexed length to be increased by twice the increment. Although in the exemplification of the invention, I have started to build up the magnetic core by first forming the innermost U-shaped lamination sections, it will be appreciated that the reverse procedure may be followed, and the core be built up by first starting with the largest or outermost lamination sections.

In accordance with the present invention, successive lamination sections are progressively built up by varying the indexed lengths by increments proportional to the actual thickness as determined by the strip gauging element 28. The dimensions of the first or the innermost U-shaped lamination section are fixed by positioning the cam cylinders 32, 33, 34 so that when the indexing unit 31 is moved from a position where it butts against the stop 44 to a position where the cam follower 38 engages the cam surface 37, a sufficient amount of strip material is indexed to form the first leg portion of the U-shaped lamination section, as is shown in FIGURE 3. After the first length is indexed, the forming brake assembly 25 is actuated, and the strip material is bent to form the first leg portion 45. When the cam follower 38 is moved from its position of engagement with the first cam surface 37 to the second cam surface 36, the amount of material required for the cross member of the U-shaped lamination section is indexed as is shown in FIGURE 5. In FIGURE 6 I have shown the forming brake assembly 25 actuated to provide a ninety degree bend in the strip material at the second indexed length to thereby form the cross member 46 of the lamination section.

Moving the cam follower 27 to a position of engagement with the third cam surface 35 causes a sufficient amount of strip material to be fed out for the second leg portion 47. The shearing mechanism 26 is now actuated to cut off the lamination section as is shown in FIGURE 8. Thus, the first lamination section is completely formed. Since the complementary U-shaped lamination section in the same layer has the same dimensions, the angular setting of the cam cylinder is not changed to form this next lamination section.

It will be seen from FIGURE 8 that after the lamination section is cut off, the left end of the strip material 30 is in line with the cutting edge of the shearing blade 49. To repeat the operations, the indexing until 31 is released from its locking engagement with the strip material 30 by turning the control knob 50. The indexing unit 31 is brought back to its starting position where it butts against the stop 44. When in this position, the indexing unit 31 is locked into engagement with the strip material 30 and is moved to the left until the cam follower engages the first cam surface 37 to index the length of the first leg portion, as is shown in FIGURE 3. The operations shown in FIGURES 4–8 are then repeated to form the second lamination section of the first layer.

After the first U-shaped lamination sections for the innermost layer of the core are formed, an angular rotation is imparted to the three cam cylinders 32, 33, 34 by the lever arm 41 so that the three indexed lengths are increased by increments proportional to the actual thickness as guaged by the strip thickness gauging element 28. It will be understood that when the indexing, forming and shearing operations are being carried out, the cam cylinders 32, 33 and 34 are locked in position. In order to impart the desired angular rotation to the cam cylinders 32, 33, 34 after a lamination layer is completed, the lever arm 41 is first released from its engagement with the shaft 43.

It will be noted that a spring 51 biases the rocker arm 40 so that the gauging blade 39 is held in contact against the strip material. Also, a spring 52 maintains the lever arm 41 in contact with the end of the rocker arm 40. Thus, when the lever arm 41 is released for rotation, a rotation proportional to the thickness of the strip material is imparted to the lever arm 41. When rotated to this position, the rocker arm 41 is locked into engagement with the shaft 43 and is rotated in a counterclockwise direction, as seen in the view of FIGURE 3, until it abuts against the stop 42. An angular rotation, that is proportional to the distance between the end of the rocker arm 41 and the stop 42, is imparted to the cam cylinders 32, 33, 34. Since the rocker arm 41 increases and decreases this distance proportionally as the thickness of the stop material varies, the angular rotation is also proportional to the actual thickness. The cam surfaces 35, 36 and 37 are designed so that the angular rotation results in an increase in the first indexed length (provided by cam surface 37) of one increment. This increment is equal to the actual thickness plus a space factor, which may be included by adjusting the position of stop 42, as will hereinafter be more fully explained. Further, cam surface 36 is designed so that the angular rotation produces an increase in the second indexed length that is twice the increment, and cam surface 35 is designed to vary the third indexed length by one increment.

Preferably, after the angular adjustment of the cam cylinders 32, 33, 34 has been made, the shaft 43 is locked in position, the lever arm 41 is released from its engagement with the shaft 43 and locked in an angular position so that the gauging blade 39 is disengaged from its contact with the stop material. The angular position of the cam cylinders 32, 33, 34 is set for forming the lamination sections of a succeeding lamination layer, and the indexing, forming and shearing operations illustrated in FIGURES 3–8 are carried out to make the lamination sections of the succeeding layer.

Having more specific reference to FIGURES 9–16, the machine disclosed herein by way of a specific exemplification of the invention will now be more fully described. I have identified the parts in FIGURES 9–16, which correspond to the parts illustrated diagrammatically in FIGURES 3–8, by the same reference numerals. The machine, as shown in FIGURE 9, is generally identified by the reference numeral 60 and is supported on a table 61 at a height convenient for manual operation.

Referring now more particularly to FIGURE 9, it will be seen that the strip material 30 is supplied from a roll 62 carried on a turntable 63. The turntable 63 is supported by a horizontally extending bracket 64 attached to the table 61. When the roll 62 of strip material is placed on the turntable 63 and fed into the machine 60, the strip material 30 is positioned so that the lower edge of the strip material 30 in the machine 60 and the bottom side of the roll 62 will lie essentially in the same horizontal plane. As the strip material 30 is unwound from the roll 62, the turntable 63 revolves to prevent any undue strain from being applied to the strip material 30 as it is drawn through the machine 60. Four adjustable ver-

tical posts 65 are provided to keep the strip material on the turntable 63 as it unreels.

The strip material 30 is maintained in an essentially vertical position by a pair of lower guide plates 66 supported by the vertical frame members 67 and 68. The upper guide plates 69 are provided to allow relatively wider strip material to be handled by the machine 60. A vertical guide post 70 is provided at a point adjacent to where the strip material 30 enters the strip thickness gauging member 28.

As is shown in the view of FIGURE 9, the handle 90 of the lever arm 40 of the strip thickness compensating assembly is located at the right side of the machine 60 where it can be conveniently operated. The control knob 92 is provided to lock and unlock the shaft 43 which carries the cam cylinders 32, 33 and 34 of the strip length indexing assembly 27. The shaft 43 is rotatably supported by the frame members 73 and 74 and is rotatable when unlocked. The three cam cylinders 32, 33, 34 are adjustably secured to the shaft 43 so that the axial position of the cylinders can be changed to accommodate various core designs. An arm 76 is also mounted on the shaft 43 to provide a limit for the angular rotation of the shaft 43. When the arm 76 butts against the stop 77 any further angular rotation of the cam cylinders 32, 33, 34 in one direction is restrained. For the convenience of the operator in setting the position of the cam cylinders 32, 33, 34, a scale 84 is mounted in a horizontal position between the frame members 73 and 74.

For a given angular position of the cylinder 32, 33, 34, three lengths of strip material are indexed when the indexing unit 31 is moved from its initial position against the stop 44 and when cam follower 38 is successively brought into contact with the cam surfaces 37, 36 and 35. It will be seen that the indexing unit 31 is carried on a pair of rails 78, 79. When the indexing unit 31 is locked in engagement with the strip material 30, as it is moved the indexing unit 31 feeds the strip material 30 to the forming brake assembly 25 in the desired indexed lengths. When the indexing unit 31 is moved from the stop 44 so that the cam follower 38 engages the first cam surface 37, the first length of the lamination section is indexed, and when it is moved to engage the second and third cam surfaces 36 and 35, the second and third lengths of the lamination section are indexed. The indexing unit 31 can be disengaged from the strip material 30 by turning the control knob 50.

In the view shown in FIGURE 9 only the control handle 81 and the control valve 82 of the shearing mechanism are shown. When the control handle 81 is in the position as shown, the shearing blade of the shearing mechanism, as will hereinafter be more fully explained in connection with FIGURE 16, is in the standby condition, and the shearing blade is actuated to its cutting position when the handle is actuated by the operator who stands in front of the machine 60. The operating handle 83 actuates a gripping element and is turned by the operator just before each forming and shearing operation so that the strip material 30 is firmly clamped in position when a forming or shearing operation is carried out.

Continuing now with a more detailed description of the component assemblies of machine 60, I will now refer more particularly to the views illustrated in FIGURES 10–16. As is shown in FIGURE 10, the gauging rocker arm 40 is rotatably supported by the brackets 86 and 87. The gauging blade 39 is sufficiently long to accommodate strip material of various widths. In the illustrated exemplification of the invention the rocker arm 40 was proportioned so that a $\frac{1}{100}$ of an inch displacement of the gauging blade 39 produced a $\frac{1}{10}$ of an inch displacement of the contact member 88 attached to the rocker arm 40. The spring 51 attached at one end to a bracket 89 and at the other end to the rocker arm 40 biases the gauging blade 39 into engagement with the strip material 30 when the lever arm 41 is released for rotation and an angular adjustment is to be made to the cam cylinders 32, 33 and 34.

It will be appreciated that when the indexing, forming and shearing operations are being carried out, the gauging blade 39 is normally disengaged from contact with the strip material 30. This is accomplished by rotating the lever arm 41 in a clockwise direction, as seen in FIGURE 10, to force the rocker arm 40 to pivot and disengage the gauging blade from the strip material 30. A spring 52 attached at one end to the frame member 74 and attached at the other end to the lever arm 41 biases the lever arm 41 into engagement with the contact member 88 of rocker arm 40. A handle 90 is attached to the lever arm 41 in order that the operator can conveniently move the lever arm 41 from a position of contact with the contact member 88 to the stop 42 or vice versa. A set screw 91 controls the stop 42 to permit adjustments to be made in order to provide a space factor for the assembled core if desired.

As will best be seen in FIGURE 11, the shaft 43 is locked in a given angular position by the control knob 92. When control knob 92 is turned in one direction it will be seen that a slug 93 is pressed against a disc 94 which is rigidly secured to the shaft 43. When the control knob 92 is turned in a reverse direction, the slug 94 is released from engagement with the disc 94, and the shaft 43 is free to rotate. The other control knob 95 permits the lever arm 41 to be engaged and disengaged from the disc 94. When the lever arm 41 is engaged or locked against the disc 94 and the operator moves the handle 90, the shaft 43 will rotate, and an angular rotation will be imparted to the cam cylinders 32, 33, 34. When the lever arm 41 is disengaged from the disc 94, it is free to rotate about the shaft 43. It will be understood that when the indexing, forming and shearing operations are performed by the operator, the control knob 92 is in the locked position. When the strip material 30 is being indexed, the handle 90 of the lever arm 41 is pushed over in a clockwise direction, as seen in FIGURES 10 and 12, to cause the gauging blade 39 to be withdrawn from contact with the strip material 30, and the control knob 95 is turned to lock the lever arm 41 in this position.

Turning now more specifically to the strip length indexing assembly 27, as shown in FIGURES 12, 13, 14, this assembly will now be more fully described. It will be seen that the cam cylinders 32, 33, 34 are secured for rotation with the shaft 43 by a suitable means such as key 96. It will be noted that a portion of the cam surface 35 of the cam cylinder 32, as will be seen in FIGURE 12, overlies the cam cylinder 33. A small handle 98 is provided on the indexing unit 31 so that the unit 31 can be moved by the operator along the rails 78 and 79. The indexing unit 31 is locked into engagement with the strip material 30 by turning the control knob 50.

As is shown in the fragmentary view of FIGURE 13, when control knob 50 is turned in one direction the block 99 exerts a compressive force against an angle-shaped element 100, which in turn is forced against the strip material 30. The indexing unit 31 is thereby secured in engagement with the strip material 30 so that as the indexing unit 31 is moved on the rails 78 and 79, the strip material 30 is carried with the indexing unit 31. It will be seen that the angle-shaped element 100 positions the strip material 30 and cooperates with the rod 97 of the adjustable positioning member 110 (shown in FIGURES 10 and 12) to maintain the horizontal alignment of the strip material 30.

Referring now more particularly to the sectional view of the indexing unit 31 shown in FIGURE 14, it will be noted that the cam follower 38 is provided at the upper end with a swivel 101 to cause the cam follower 38 to be retracted to various positions. When the swivel 101 is in the horizontal position as shown in FIGURE 14, the cam follower 38 will engage the first cam surface 37. The swivel 101 is rotated to a second position, the cam

follower 38 is retracted, and will engage the second cam surface 36. In a third position the swivel 101 will cause the cam follower 38 to be further retracted so that the cam follower 38, when moved by the operator towards the forming brake assembly, will pass over the cam surface 36 and engage the cam surface 35.

In FIGURE 15 I have illustrated a fragmentary view of the cam follower 38 to illustrate the specific details of its construction. It will be seen that a pair of V-shaped axially extending grooves 102 and 103 are formed on the cylindrical periphery of the cam follower 38. A ball bearing 104 is normally biased into either of the grooves 102 or 103 so that one of the contact points 106 or 107 may be used. The ball bearing 104 and the spring 105 function as a detent means to releasably engage the cam follower 38 in one of two angular positions. It will be noted that the contact point 106 is at a shorter radial distance from the central axis of the cam follower 38 than contact point 107. The purpose of this arrangement is to make it conveniently possible for the operator to vary the length of the leg portions of lamination sections by a fixed amount. For example, where it is desired to form a bridged gap in the preformed magnetic core, the length of a leg portion of the lamination sections may be shortened so that when the lamination sections are assembled, the shorter leg portion will be spaced from the end of the lamination section in the same lamination layer to define an air gap. Also, it will be apparent that by varying the lengths of the legs staggered joint configurations can be achieved as may be desired in a particular core design.

Although I have shown only two contact points 106 and 107 on the cam follower 38, it will be understood, of course, that additional contact points and slots may be formed in the cam follower 38 as may be required for forming the lamination sections of a specific core design.

Having more specific reference to FIGURE 16, I will more fully describe the component assemblies that carry out the forming and shearing operations of the machine 60. It will be seen that the strip material 30, as it is indexed, is fed out beyond the guide member 108 and along the forming brake shoe 55. The shoe 55 is pivotally carried by the rotating support member 10 which allows the shoe 55 to pivot essentially about a vertical axis and form bends in the strip material 30. Thus, the strip material 30 is bent to a substantially right angle by swinging the shoe 55 to the position shown in dished outline where it butts against the stop screw 112. As was previously mentioned, the laminations sections may be formed with an inside angle that is slightly less than 90 degrees so that the leg portions of successive lamination sections will engage the lamination sections on which they are superposed with a clamping action.

The shearing mechanism 26 is comprised of a crank shaft 113 which is journaled in the bearings 114 and 115 carried by the frame members 140 and 141. The shearing blade 49 is driven by the crankpin 116 actuated by a lever 117 keyed to the crank shaft 113. The alignment of the shearing blade 49 is maintained by four adjustably supported guide blocks 118, 119, 120 and 121. A hardened cutting blade insert 122 is attached to the shearing blade 49 to permit the insert 122 to be readily removed for servicing. As the lever arm 117 is raised or lowered, it will be seen that as crank shaft 113 rotates, the shearing blade 49 is driven through the strip material 30, and a shearing action is effected.

As is shown diagrammatically in FIGURE 16, the lever arm 117 is actuated by a pneumatic piston and cylinder assembly 123 which is mounted in a housing 124 attached to a support plate 125. A pair of control lines 126 and 127 are brought out to the control valve 82 mounted near the front side of the machine. The control valve 82 is connected to a source of compressed air (not shown). When the control handle 81 is in the position shown in FIGURE 16, the air supplied to the piston and cylinder assembly 123 is such that the shearing blade 49 is maintained in the withdrawn position as shown. When the handle 81 is moved inwardly to actuate the control valve 82, the air flow to the piston and cylinder assembly 123 is reversed, and the lever 117 is raised to actuate the shearing blade 49.

In order to firmly position the strip material 30 so that the forming and shearing operations can be carried out without unduly straining, misaligning or distorting of the strip material 30, I have provided a gripping element 130. The gripping element 130 swings in and out of engagement with the strip material 30 and is carried on a pivotally supported vertical shaft member 131. A spring 132 biases the gripping element 130 away from the strip material 30. A shaft 133, which is attached to the handle 83 (shown in FIGURE 9) is formed with an eccentric portion 134. When handle 83 is turned, the eccentric portion 134 forces the gripping element 130 against the strip material 30 and thereby securely clamps the strip material 30 so that the forming and shearing operations can be properly carried out.

From the foregoing description, it will be apparent that the present invention makes it possible to readily fabricate the lamination sections of preformed magnetic cores. Although in the illustrated exemplification of my invention I have shown and described a core forming machine specially adapted for manual operation, it will be appreciated that the basic operations performed by the manual operation of the machine are adaptable to automated and semiautomated manufacturing techniques. Further, the particular embodiment of my invention, which I have disclosed, clearly illustrates the principles of operation of the invention, and as a result of this disclosure many modifications will be apparent to those skilled in the art. Accordingly, it is to be understood that I intend by the appended claims to cover all such modifications that fall within the true spirit and scope of the invention.

What I claim as new and desired to secure by Letters Patent of the United States is:

1. In a machine for making laminations for magnetic cores with lamination layers formed of pairs of lamination sections, each of the lamination sections having a pair of leg portions and a cross member joining said leg portions, a strip material supply means, a strip thickness gauging means for measuring the actual strip thickness, a strip length indexing means for indexing a first, second and third length of strip material, said first length forming one leg portion, said second length forming said cross member, and said third length forming the other leg portion of a lamination section, means coupled with said indexing means for adjustably varying the indexed lengths by an increment proportional to the actual strip thickness as determined by said gauging means to provide a first and a third indexed length for lamination sections of a succeeding lamination layer that differs from the first and third lengths of the lamination section of a preceding lamination layer essentially one increment proportional to the strip thickness, and to provide a second indexed length for lamination sections of the succeeding lamination layer that differs from the second length of the lamination section of a preceding lamination layer by essentially two increments thereby to progressively provide the indexed lengths for each successive layer by alteration of said lengths by said respective increments between the formation of each successive lamination layer, forming means for bending said strip material at said first and second indexed lengths, and means for shearing said strip material at the third indexed length to cut off said lamination sections.

2. In a machine set forth in claim 1 wherein said strip length indexing means includes a cylindrical cam means having a first, second and third cam surface for indexing said first, second and third lengths of a lamina-

tion section, said cylindrical cam means being adjustably rotatable to cause said first and third indexed lengths to be changed by said one increment and to cause said second indexed length to be changed by twice said increment.

3. In a machine for making laminations from strip material for magnetic cores with lamination layers formed of a pair of preformed sections, each of the preformed lamination sections having at least a first and a second leg portion, a strip material supply means, a strip thickness gauging means for measuring the actual thickness of the strip material, a strip length indexing means for controllably feeding out a first and a second indexed length of strip material to provide the material for the first leg portion and the second leg portion respectively of a preformed lamination section, means coupled with said indexing means for adjustably varying the first and second indexed lengths by increments proportional to the actual thickness as determined by said strip thickness gauging means to provide a first and second indexed length for lamination sections of a succeeding layer that differs from the first and second indexed lengths of the lamination sections of a preceding lamination layer by at least one thickness thereby to progressively provide the lengths for each successive layer by alteration of said lengths by said respective increments between the formation of each successive lamination layer forming means for bending the strip material to form the leg portions of the lamination section, and means for shearing the strip material at the second indexed length to cut off said preformed lamination section from said strip material.

4. In the machine set forth in claim 3 wherein said indexing means includes a cylindrical cam means having at least a first and second cam surface for indexing said first and second indexed lengths of a lamination section, said cylindrical cam means being adjustably rotatable to change said first and second indexed lengths by at least one increment.

5. In a machine for making laminations from strip material for a magnetic core with lamination layers formed of pairs of lamination sections, each of the lamination sections having a first and a second leg portion bent substantially at right angles to form a cross member joining the first and second leg portions, a strip material supply means, a strip thickness gauging means for determining the actual thickness of the strip material; a strip length indexing means for feeding a first, a second and a third indexed length of strip material to provide the strip material to form the first leg portion, the cross member and the second leg portion respectively of a lamination section, means cooperating with said gauging means and said indexing means for adjustably changing the first and third indexed lengths in increments proportional to the actual thickness of the strip material as determined by said gauging means to provide a first and a third indexed length for a lamination section of a succeeding lamination layer that differs by essentially one thickness from the first and third lengths of a lamination section of a preceding lamination layer and to provide a second indexed length for said succeeding lamination section that differs by essentially two thicknesses from the second indexed length of the lamination section of the preceding lamination layer to progressively provide the lengths for each successive layer by alteration of said lengths by said respective increments between the formation of each successive lamination layer, forming means for bending the strip material at the first and second indexed lengths, and means for shearing said strip of material at the end of said third indexed length to cut off said U-shaped lamination section from said strip material.

6. In the machine set forth in claim 5 wherein said indexing means includes a cylindrical cam means having a first, second and third cam surface for indexing said first, second and third indexed lengths of a lamination section, said cylindrical cam means being adjustably rotatable to provide a step for changing said first and third indexed lengths by one increment and for changing said second indexed length by essentially twice said increment.

7. A machine for making laminations from strip material for magnetic cores comprised of layers formed of pairs of lamination sections, said machine being comprised of: a strip supply means, a forming means for bending the strip material substantially at right angles, a shearing means for cutting off the lamination sections from the strip material, indexing means for feeding a first, second and third indexed lengths of the strip material to the forming and shearing means, said indexing means including a cylindrical cam means formed with a first, second and third cam surfaces for indexing said first, second and third indexed lengths of a lamination section, a cam rotating arm operatively associated with said cylindrical cam to impart an angular rotation thereto, a strip thickness gauging rocker arm pivotally supported for engagement with the strip material at one end thereof and at the other end thereof for providing a stop for said cam rotating arm, said cam arm when engaged with said stop thereby imparting an angular rotation to said cylindrical cam means proportional to the actual thickness of the strip material as determined by said rocker arm, and said angular rotation causing said first and third cam surfaces to change the first and third indexed lengths of a lamination section by an increment proportional to the actual thickness of the strip material and causing said second cam surface to change the second indexed length by twice said increment.

8. A machine for making laminations from a strip material for magnetic cores comprised of lamination layers formed of at least a pair of complementary lamination sections, said machine comprising: a strip supply means, a forming means for bending the strip material substantially at right angles, shearing means for cutting off the lamination sections, a strip length indexing means for feeding the strip material in at least a first and second indexed length to said forming means and said shearing means, said strip length indexing means including cam cylinders formed with cam surfaces for indexing said first and second lengths of said lamination sections, said cam cylinders being adjustably rotatable to change said indexed lengths by increments proportional to the thickness of the strip material, a strip thickness gauging means for determining the actual thickness of the strip material, and means cooperating with said strip length indexing means and said strip gauging means for changing the indexed lengths of said strip material in increments proportional to the actual thickness as determined by said strip thickness gauging means.

9. In a machine for making laminations from strip material for a magnetic core comprised of lamination layers formed of pairs of preformed sections, a forming means for bending the strip material at substantially right angles, a shearing means for cutting off the formed lamination sections from the strip material, an indexing means for feeding indexed lengths of the strip material to said forming and said shearing means, said indexing means including cam cylinders formed with cam surfaces for indexing said lengths of said strip material, said cam cylinders being adjustably rotatable to change said indexed lengths by said increments, gauging means for measuring the thickness of the strip material before it is suppled to the forming and shearing means, and means coupled with said indexing means to vary said indexed lengths of strip material by increments proportional to the actual thickness of the strip material as determined by said gauging means.

10. A machine for making laminations from strip material for magnetic cores comprised of layers formed of pairs of U-shaped lamination sections said machine comprising: a strip supply means, a forming means for form-

ing substantially right angle bends in the strip material, a shearing means for cutting off the lamination sections from the strip material, indexing means for feeding a first, second and third indexed lengths of the strip material to said forming means and said shearing means, said indexing means including cylindrical cam means having a first, second and third cam surface for indexing said first, second and third indexed lengths, said cylindrical cam means being adjustably rotatable to change said first and third indexed lengths by one increment and to change said second indexed length by twice said increment, a strip gauging means for determining the actual thickness of the strip material, and means coupled with said indexing means to adjustably change the first and third indexed lengths by one increment proportional to the actual thickness of the strip material as determined by said gauging means and to change said second indexed length by twice said increment.

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