May 26, 1970 A. F. MITTERMAIER ETAL 3,513,523

MACHINE AND METHOD FOR FORMING LAMINATIONS FOR MAGNETIC CORES

Filed April 20, 1967 3 Sheets-Sheet 1

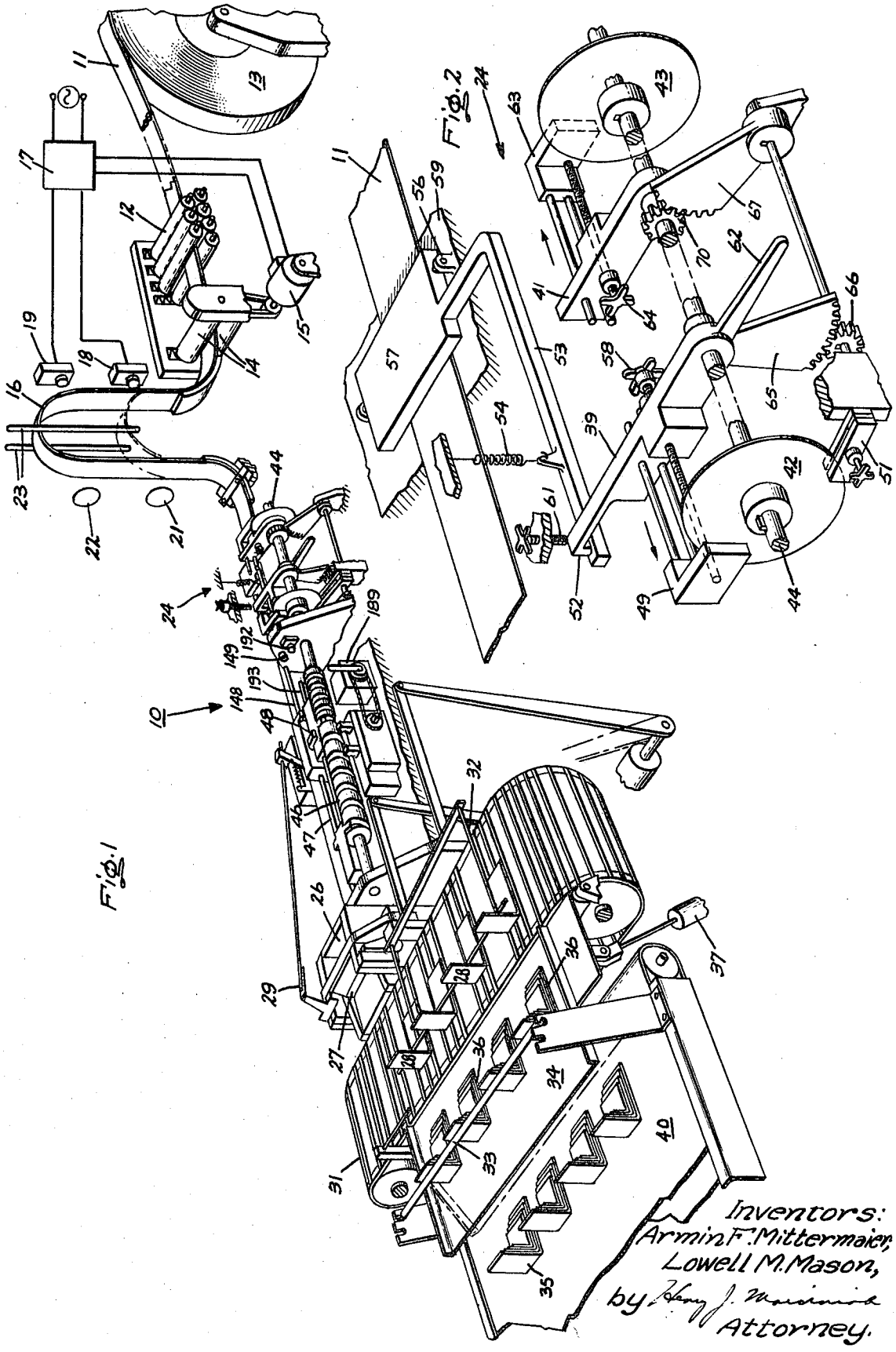


Fig. 1

Fig. 2

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Fig. 5

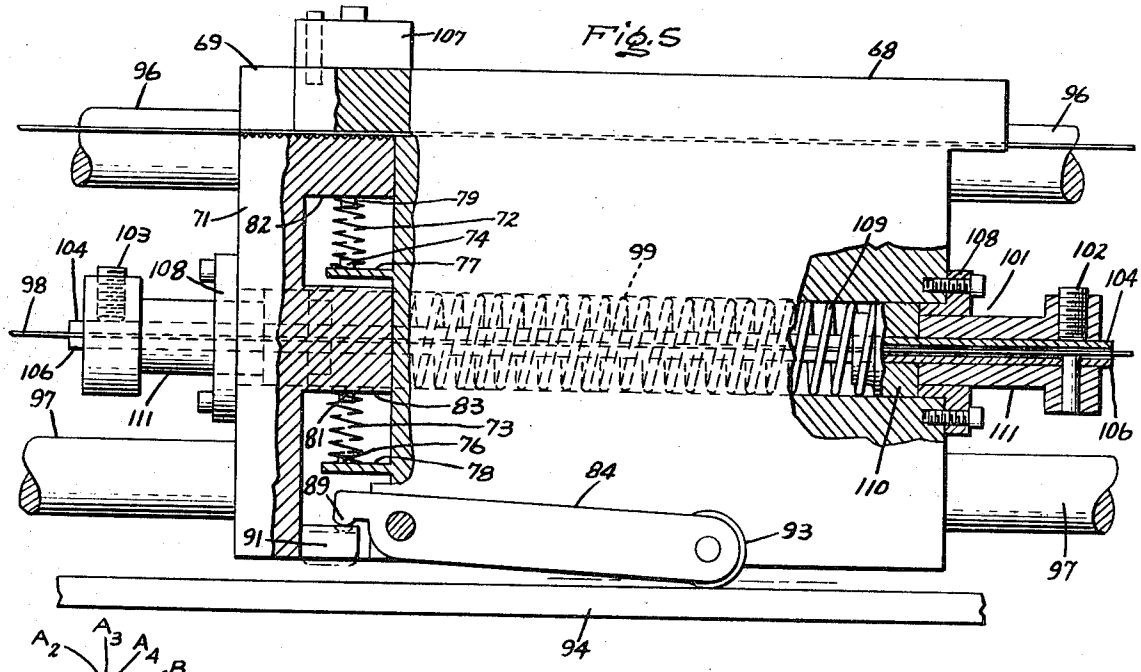


Fig. 3

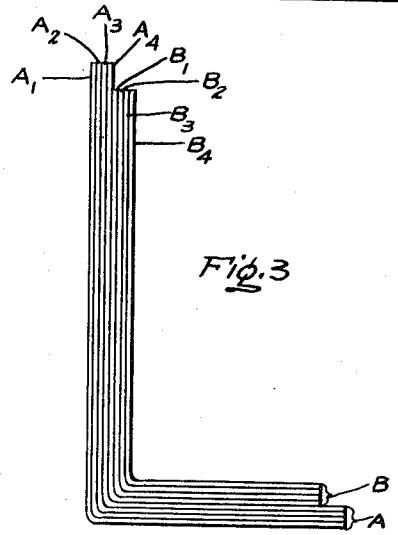


Fig. 4

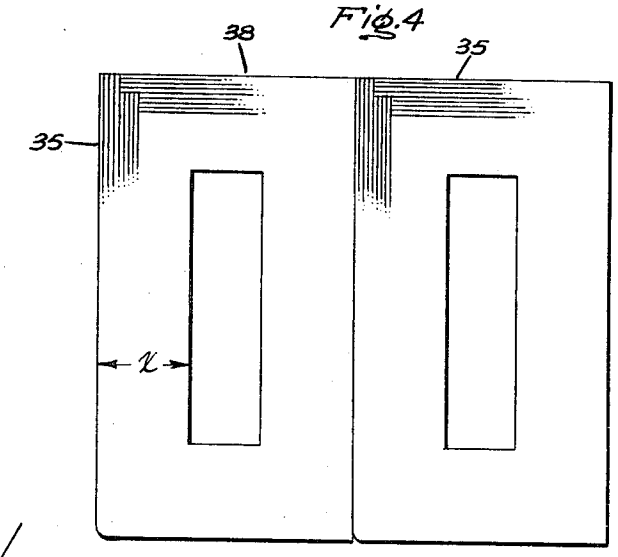
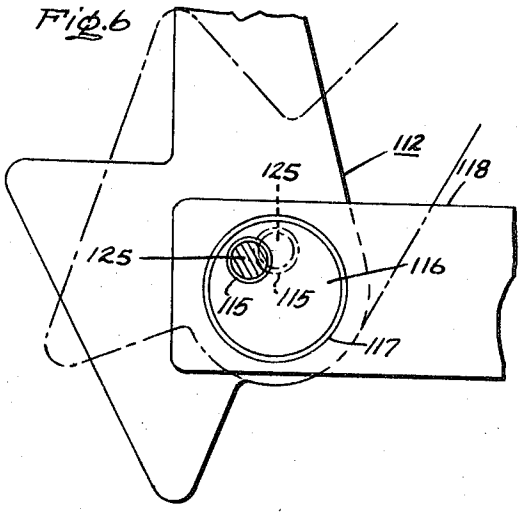


Fig. 6



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MACHINE AND METHOD FOR FORMING LAMINATIONS FOR MAGNETIC CORES

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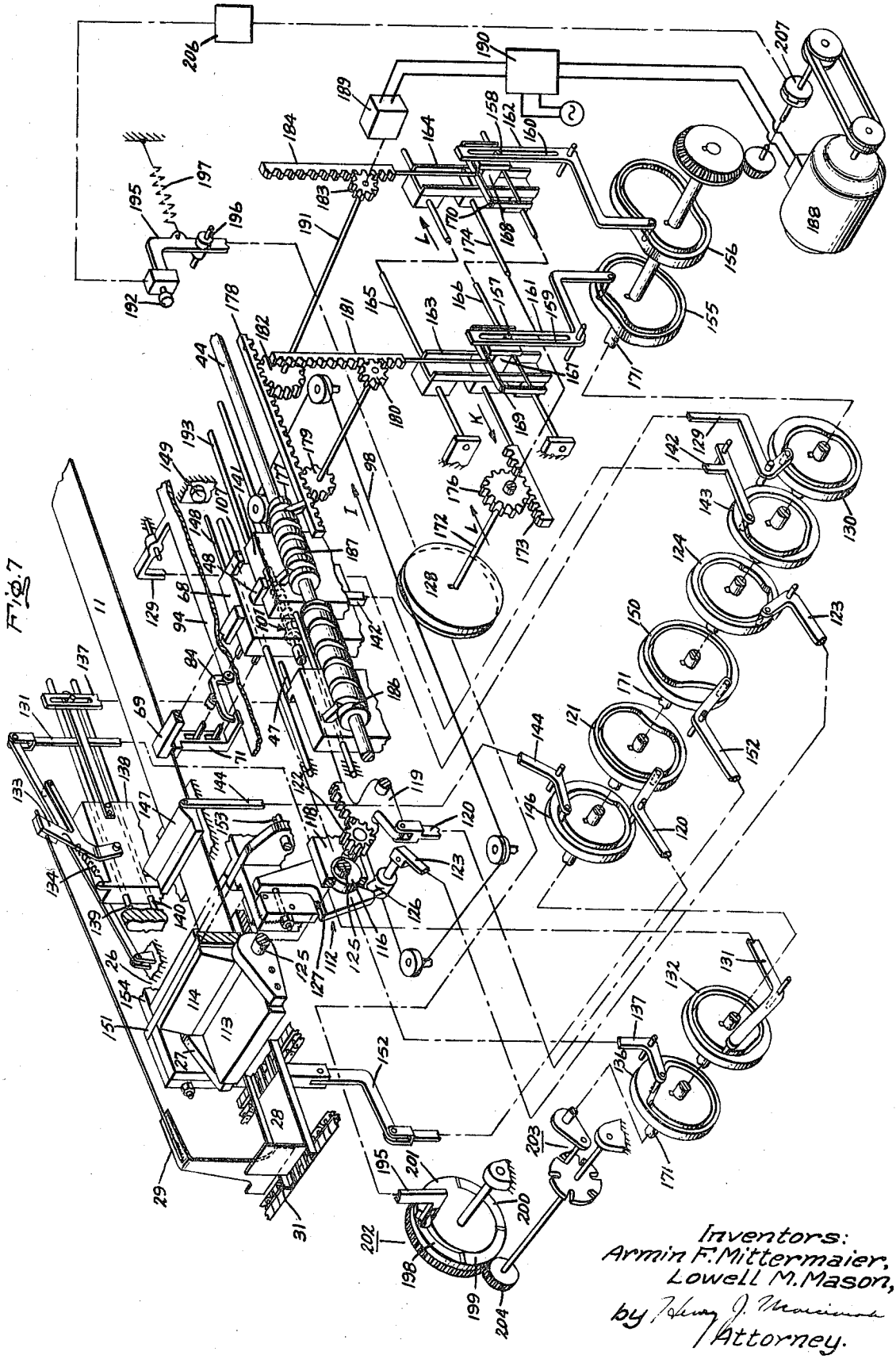


Fig. 7

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MACHINE AND METHOD FOR FORMING LAMINATIONS FOR MAGNETIC CORES

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Int. Cl. H01r 43/04
U.S. Cl. 29—203 10 Claims

ABSTRACT OF THE DISCLOSURE

A gripper carriage is driven by a variable drive train to advance an end portion of magnetic strip material from an upstanding loop of strip material until the gripper carriage engages a first index stop with a spring-biased engagement. With the gripper carriage biased against the stop, a first preselected length of the strip material is indexed for forming the first leg of a lamination. The indexed end portion of the strip material is bent at right angles by a forming shoe. A shoe release mechanism prevents the forming shoe from dragging the strip material and opening the bend. The gripper carriage then advances a second preselected length of strip material until a second index stop is engaged by the carriage with a spring-biased engagement thereby to feed out the strip material for the second leg of the lamination. The formed lamination is then severed and deposited on an indexing conveyor. These operations are repeated until a predetermined number of laminations are formed and deposited on the indexing conveyor. The laminations are then transferred by an ejecting bar to a stacking table.

In order to ensure a positive feed without shearing the index stops or a portion of the gripper carriage drive train as the positions of the stops are varied, the travel of the gripper carriage is correspondingly varied. A computing section of the machine computes the height of the core as laminations are formed and initiates recycling of the machine when the desired stack height has been attained.

BACKGROUND OF THE INVENTION

This invention relates to machines and methods for forming laminations for magnetic cores. More particularly, it relates to improvements in 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 the mass production of transformers using cores made from preformed laminations, it is desirable, if not necessary, to feed strip material through a machine at relatively high speeds in order to achieve the desired production rates. It will be appreciated that the strip material advancing mechanism of a machine producing preformed laminations must accelerate rapidly from a dwell position to a maximum speed and then decelerate to a second dwell position in the process of indexing the strip material. This starting and stoping will usually occur at least three times in the production of each individual lamination in a core.

In the past, when attempts have been made to feed strip material through a forming station at high speeds, one of the problems encountered has been the tendency of the forming shoe to drag on the bent material and open the bend.

Where the strip material is indexed by butting the end of the strip material against a stop, a problem has been encountered in accurately positioning the strip material at the forming and severing stations without distorting the material. It is therefore desirable to provide a machine that will rapidly position the strip material but does not require that the strip material be butted against a fixed stop. It is also desirable that the machine be capable of handling the strip material at high rates of speed so that the overall production rate of the machine is maximized. In addition, it is desirable that the actual overall core dimensions and weight of steel in each core be held within design tolerances.

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

Another object of the invention is to provide an improved machine and method for making preformed laminations for a magnetic core wherein the production rate of the machine is maximized.

It is a more specific object of the present invention to provide a machine and method for making preformed laminations for a magnetic core wherein material is supplied without unduly straining the feeding mechanism.

SUMMARY OF THE INVENTION

In accordance with one form of our invention, we have provided an improved machine for making laminations from strip material wherein a gripper carriage advances the strip material from a strip material supply means to a forming station. To provide the preselected lengths of strip material required to form the legs of the lamination, the gripper carriage is successively driven against a first and a second stop. The forming station includes a mandrel and a forming shoe, the forming shoe being supported for translational and angular movement relative to the mandrel. When the gripper carriage is against the first stop to feed out the first preselected length of strip material, the forming shoe is actuated with an angular movement to bend the first preselected length of strip material and the forming shoe is initially disengaged from the strip material with a translational movement thereby to prevent dragging the forming shoe against the material.

The improved machine also includes a means for indexing the stops to vary the preselected lengths of lamination formed for successive lamination layers. As the positions of the stops are varied to change the preselected lengths, the travel and speed of the gripper carriage is correspondingly varied. After the strip material is advanced by the gripper carriage against the second stop to provide the second preselected length of strip material, the bent end portion is then severed to form a lamination, the first preselected length forming one leg of the lamination and the second preselected length forming the other leg of the lamination.

In accordance with a more specific aspect of our invention, we have provided a strip supply arrangement utilizing an upstanding loop of strip material from which the gripper carriage draws its supply of strip material. The height of the loop is maintained within predetermined high and low limits by supplying strip material to the loop when the height of the loop falls below the lower limit. When the height of the loop reaches the upper limit, the supply of strip material from a strip material source, such as a reel, is stopped.

According to another aspect of our invention, the forming shoe is supported by eccentrically mounted bearings for translational and angular movement relative to the mandrel. The bending operation is carried out at the forming station by imparting a rotational movement to the forming shoe, and the forming shoe forces the strip material against the mandrel thereby bending the strip, material. To release the forming shoe, a translational

movement is imparted to the shoe by rotating the eccentrically mounted bearings. In this way, dragging of the material is prevented. After this initial translational movement, the forming shoe is rotated to its rest position.

For transferring laminations to a stacking station, we have provided a positioning conveyor that arranges the laminations in a prestacking position for transfer to the stacking station, the laminations being ejected from the prestacking position into stacked relationship on the stacking station. In this manner, a predetermined number of core sections, equal to the number of laminations in the prestacking position, are progressively built up.

In still another aspect of the invention, we have provided an improved method for making the lamination sections of a preformed magnetic core. In carrying out the method of the invention, laminations are formed at the forming station with a first and a second leg portion substantially at right angles to each other. A preselected number of substantially identical laminations are formed and positioned at individual stacking stations to form a first set of laminations. Subsequently, additional sets of substantially identical laminations are formed and stacked, one each, on the laminations previously positioned at each of the stacking stations. In the practice of our method, a free loop of strip material is maintained and the material is selectively advanced a first distance as determined by a first indexable stop; formed; released; advanced a second distance as determined by a second indexable stop; and severed in order to form each lamination. These steps are repeated to produce the requisite number of substantially identical laminations comprising each set.

The step of forming the strip material includes the step of positioning the material between a forming shoe and forming mandrel, and rotating the forming shoe on a shaft after moving the shaft toward the center of bend for the strip material. The bent strip material is then released by returning the shaft to its initial position and then rotating the shaft to return the forming shoe to its initial position.

After the last lamination for each set of laminations is completed, the indexable stops are moved incremental distances to determine the length of the legs of subsequent substantially identical laminations. The indexable stops serve as guides and present limits for the movement of a strip material gripper carriage.

In the practice of the invention, the strip material is grasped by the gripper carriage and it in turn is advanced a first distance to engage the first indexable stop with a spring-biased engagement. After the strip material has been formed, the gripper carriage is advanced a second distance to engage the second indexable element with a spring-biased engagement. Then the strip material is severed and the gripper carriage is returned to its initial position.

The subject matter which we regard as our 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:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view illustrating a machine embodying our invention and groups of formed laminations being stacked in accordance with the improved method of the invention;

FIG. 2 is a mechanical schematic view, in perspective of the strip material thickness gauging station and indexing shaft for positioning indexable stops in the machine of FIG. 1;

FIG. 3 is an elevation showing the stacked relationship of laminations produced by the machine of FIG. 1;

FIG. 4 is an elevational view and shows the build of a core assembled from laminations produced by the machine illustrated in FIG. 1;

FIG. 5 is an elevation, with parts broken away, of a gripper carriage used in the machine of FIG. 1; and

FIG. 6 is an elevation, with parts in section, showing the forming shoe release mechanism used in the machine of FIG. 1; and

FIG. 7 is an exploded mechanical schematic of the drive mechanism for the machine of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIGS. 1 and 2, strip material **11** is pulled through a roller leveler **12** from a strip material supply **13** by pinch rollers **14** powered by motor **15**. In order to reduce strain on the machine **10**, we maintain a free loop **16** of material by using a suitable control apparatus for the motor **15**. In the exemplification, the control apparatus is illustrated as including a control circuit **17**, a pair of photo-cell scanning units **18**, **19** and a pair of targets **21**, **22**.

During operation, the motor **15** is de-energized when the free loop **16** attains a height sufficient to interrupt the beam of light between the scanning unit **19** and target **22**. As the material is fed out of the free loop **16** the loop drops down between guide bars **23** until the loop no longer interrupts the beam of light between photo-cell unit **18** and target **21**. At this time, the windings of motor **15** are re-energized and additional strip material **11** is fed into the upstanding or free loop **16** until the upper light beam between photo-cell unit **19** and target **22** is again interrupted. In this manner, the upstanding loop is maintained for feeding strip material through the machine **10**. It will be seen that the strip material **11** is fed through a material thickness gauging station **24**, past a severing station **26**, and to a forming station **27**. As individual laminations **28** are formed and severed from the strip material they are pushed by a transfer arm **29** onto an indexing conveyor **31**.

As the transfer arm **29** returns to an initial position, shown in FIG. 1, the indexing conveyor **31** advances one step to move a lamination **28** out of the path of the advancing strip material **11**. When the desired number of substantially identical laminations **28** have been produced for a complete set of laminations, an ejecting bar **32** pushes each set of substantially identical laminations **28** against the backstop **33** on the pivotal stacking table **34**. As the machine **10** continues to form laminations, they are then stacked on top of each other to form lamination groups **36**.

When each of the groups **36** of laminations attain the desired height of individual laminations **28** to form core sections **35**, the stacking table **34** is tilted to the dotted line position shown in FIG. 1 by an air cylinder **37** whereupon the core sections **35** slide onto an apron conveyor **40** for transfer to another location where core assembly operations may be performed.

Now having reference to FIG. 2, a more detailed description of the strip material thickness gauging station **24** will be made. The strip material thickness gauging station comes into operation in the exemplification after each set of four substantially identical laminations have been produced. The gauging station **24** is useful for making adjustments in the machine which cause each succeeding set of substantially identical laminations to differ in size from the preceding set of laminations by a predetermined amount, as will hereinafter be more fully explained.

With reference to FIG. 3, it will be seen that each of the laminations (A_1–A_4) in group A have leg lengths differing from each adjacent lamination in the same group by essentially one stock thickness. The lamination B_1, however, differs from the lamination A_4 by essentially 5 stock thicknesses. As explained in the U.S. Pat. No. 3,270,308 granted to Mittermaier this increased difference in leg length results in a stepped joint when the completed groups or core sections **35** are assembled to form a magnetic core such as core **38** in FIG. 4. It should be understood, however, that it is within the contemplation of the

present invention that any number of laminations may be produced to form lamination group A and that the difference in the leg lengths of the first lamination in one group and the last lamination of a preceding subgroup may differ by any desired amount.

Again having reference to FIG. 2, the gauging station **24** includes actuating arms **39** and **41** useful for imparting selected increments of rotation through either disc **42** or **43** to the shaft **44**. As best shown in FIG. 1, when shaft **44** and the lead screw or indexable cam **46** fixed thereto are rotated, indexable stops **47** and **48** move selected distances to determine the actual leg length of succeeding individual laminations. When motion is imparted to shaft **44** through disc **42**, shaft **44** will be rotated an amount corresponding to one stock thickness of material, whereas when motion is imparted to shaft **44** by disc **43** the shaft will be rotated an amount corresponding to five stock thicknesses of material.

When the strip material thickness gauging station **24** is not in use, or while substantially identical laminations are being produced, the clamp **49** is released from disc **42**, and the stationary clamp **51** holds shaft **44** against rotation by clamping disc **42** keyed to the shaft **44**.

While in this locked condition, the contact section **52** of the actuating arm **39** bears against the end of stock thicknesses measuring lever **53** to stretch tension spring **54** and raise gauging edge **56** of gauge block **57** from the strip material **11**.

It will be understood that for purposes of illustration and description the gauging station **24** in FIGS. 1 and 2 has been shown as being adapted for manual operation. However, it will also be understood that the various functions described above can be fully automated by the use of cams, levers, and gears timed into the main drive train of the machine **10**.

At selected times during dwells in the advance of strip material **11** through the machine **10**, the clamp **49** is manually released by handle **58** whereupon the tension spring **54** causes edge **56** of gauge block **57** to pinch the strip material **11** against the machine bed **59**. The corresponding movement of the end of the measuring lever **53** moves section **52** of actuating arm **39** upwardly an amount depending on the actual thickness of the material **11**. After movement, the section **52** of actuating arm **39** is spaced from the stop **61** by an amount proportional to the thickness of the stock at the point of measurement plus any desired space factor.

When the shaft **44** is to be rotated one incremental amount corresponding to a single stock thickness, the clamp **49** is tightened so as to lock actuating arm **39** to disc **42**, the stationary clamp **51** is released, and the handle **62** is moved manually to bring the section **52** of arm **39** into engagement with the stop **61**.

It will be understood that the motion of handle **62** is imparted to shaft **44** through disc **42** and that rotation of shaft **44** results in an indexing of stops **47** and **48**. After indexing, clamp **51** is retightened to hold the disc **42** and shaft **44**; the clamp **49** is once more released, and the handle **62** is used to release the strip material **11** for advancement through the machine.

The shaft **44** may be indexed an amount corresponding to five stock thicknesses by proceeding as above, by imparting the indexing motion through the clamp **63** and disc **43** rather than the clamp **49** and disc **42**. After clamp **49** has been released to permit actuation of gauging block **57** by the spring **54**, clamp **63** is locked to disc **43** by turning handle **64**. After release of clamp **51**, contact section **52** is moved into engagement with the stop **61** as before. The movement of actuating arm **39** is multipled by a factor of 5 through gear train **65**, **66**, **67**, **70** and transmitted to shaft **44** through clamp **63** and disc **43**.

In FIG. 5 the gripper carriage **68** is shown in detail. Strip material **11** is gripped between an upper jaw **69** integral with the gripper carriage **68** and a movable lower jaw **71** which is normally urged into a closed position by the compression springs **72**, **73**. The springs **72**, **73** are seated on pins **74**, **76** projecting from ledges **77**, **78** integral with the body of the gripper carriage **68** and on pins **79**, **81** projecting from bearing surfaces **82**, **83** on the movable jaw **71**. At selected times during the operation of the machine **10**, the movable jaw **71** is opened against the bias of the springs **72**, **73** by the action of jaw release lever **84** which is pivotally mounted on the gripper carriage **68**. The contact surface **89** of the jaw release lever **84** bears against the shelf **91** integral with the movable jaw **71** and opens the jaws when the roller **93** on the opposite end of the jaw release lever **84** is moved to the phantom line position (illustrated in FIG. 5) by the jaw release track **94**.

The gripper carriage **68** is guided for movement through the machine by guide rods **96**, **97** on which the gripper carriage **68** is slidably mounted. Motion is imparted to the gripper carriage **68** by a dimensionally stable, i.e., essentially non-stretchable driving member illustrated as a flat steel band **98**. The steel band passes through a bore **99** in the gripper carriage **68** and is releasably connected to the gripper carriage **68** through a lost motion coupler generally denoted by the numeral **101**.

Once the machine **10** has been set up, the set screws **102**, **103** are tightened against clamping flats **104**, **106** and the position of the lost motion coupler **101** relative to the steel band **98** is not changed except for occasional adjustments. When the abutment block **107** on the gripper carriage **68** engages the indexable stops **47**, **48** the movement of the gripper carriage **68** along the guide rods **96**, **97** is stopped. However, since it is extremely difficult in a high speed production machine to keep absolute tolerances and the steel band is substantially non-stretchable, it would be possible to snap the steel band or shear the abutment block **107** if the lost motion coupler **101** were not used. With the lost motion coupler **101** the further advantage results that it is possible to overdrive the steel band **98** at all times to insure that the gripper carriage **68** is driven to exactly the correct position as determined by the indexable stops **47** and **48**. In addition, minor misadjustments of the drive mechanism for steel band **98** may be tolerated because the lost motion coupler **101** will absorb any excess drive action.

The lost motion coupler **101** includes a pair of flanged collars **108** fixed to the gripper carriage at either end of the bore **99** through the carriage. Within the bore **99** a compression spring **109** is compressed between a pair of shouldered washers **110** which are held therein by the flanged collars **108**. A clamping dog **111** is slidably received in a central opening through the flanged collars **108** and the set screws **102**, **103** hold the clamping dogs **111** in position on the steel band **98**.

During operation of the machine **10** the gripper carriage **68** advances material to the left as viewed in FIGS. 1 and 5. As abutment **107** engages the indexable stops **47**, **48**, movement of the gripper carriage **68** ceases. However, with an intentional slight overdrive of the steel band **98** the left hand clamping dog **111** is moved to the left a small distance along the bore **109** and the right hand clamping dog **111** drives the right hand shouldered washer **110** along the bore **109** to compress the compression spring **99**.

When the gripper carriage is returned to an initial position the clamping dogs **111** are driven to the right relative to the gripper carriage **68**, and the spring **109** prevents damaging shock forces. With the exemplified lost motion connector **101**, the gripper carriage abutment block **107** is essentially spring loaded against the indexable stops **47**, **48** during dwell periods, and bears against the indexable stops **47**, **48** with a substantially constant predetermined pressure of engagement.

Now having reference to FIGS. 6 and 7, we will more fully describe the operation of the pressure release mechanism **112** at the forming station **27**. When strip material **11** has been advanced the first feed distance, it will move

between the forming shoe **113** and the forming mandrel **114**. A relatively wide range of thicknesses of strip material may move between the forming shoe **113** and forming mandrel **114** since the forming shoe **113** is spaced below the mandrel a distance greater than the thickness of the heaviest gauge of strip material contemplated to be bent at the forming station **27**. The forming shoe **113** is keyed to a rotatable shaft **125** which is supported in a bearing surface **115** (see FIG. 6) in the eccentric **116** which forms part of the pressure release mechanism **112**. The eccentric **116** in turn is supported in a fixed bearing **117** in the machine frame **118**. In order to bend the strip material **11**, the quadrant **119** is actuated through linkage **120** driven by cam **121** to drive pinion **122** keyed to the forming shoe shaft **125**. However, just before the quadrant **119** is actuated, the linkage **123**, driven by the cam **124**, rocks the pressure arm **126** into engagement with the pressure release mechanism **112** and rocks the pressure release mechanism **112** against the compression spring **127** held in the machine frame **118**. Thus, due to the movement of the pressure release mechanism **112** the forming shoe **113** is moved up against the strip material before the shoe rotates with shaft **125** to form the strip material **11**. Just before the quadrant **119** returns to its initial position to return the forming shoe **113**, the pressure arm **126** is released, the compression spring **127** returns the pressure release mechanism **112** to its initial position, and as the shaft **125** returns to its initial position, the forming shoe **113** moves obliquely away from the forming mandrel **114**. With this arrangement, not only can a wide range of stock sizes be accommodated, but the tendency of the forming shoe **113** to drag the bent material and open the bend is substantially eliminated.

Turning to FIG. 7, we will now describe the overall operation of the machine **10** in more detail. The strip material **11** is advanced through the machine **10** by the gripper carriage **68** through the action of capstan **128** which pays the steel band **98** off on one side and takes the steel band **98** up on the other side. As will be described more fully hereinafter, the capstan **128** not only advances the carriage **68** between dwells but also provides a fast return of the carriage **68** while the severing operation is being performed.

At the beginning of each feed cycle, the jaw release track **94** is moved downwardly, by the action of linkage **129** and the carriage cam **130**, to permit the jaws **69**, **71** to close on the strip material **11**. At about this same time, rake-off or transfer arm **29** is moved from the position shown in FIG. 7 to the position shown in FIG. 1. The rake-off arm **29** is rocked upwardly by the action of linkage **131** and lift cam **132**. With the actuation of linkage **131**, the rake-off rocker **133** stretches tension spring **134**.

While the rake-off arm is rocking up, return cam **136** rocks linkage **137** to pull the rake-off slide **138** along the guides **139**, **140**.

The gripper carriage **68** accelerates, advances the strip material **11**, and decelerates as abutment **107** on carriage **68** engages the first indexable stop **48** and excess drive action is absorbed by the lost motion coupler **101**. As the stop **48** is engaged, capstan **128** dwells momentarily, and linkages **120**, **123**, at the forming station **27** are actuated by the cams **121**, **124**, to bend the strip material **11**.

The pressure release mechanism **112** and forming shoe **113** return to their initial positions, a release lever not shown, similar to jaw release lever **84** and carried by block **141** moves the indexable stop **48** downwardly against compression springs and out of the path of abutment **107** on gripper carriage **68**. The release lever for the indexable stop is actuated by a release track connected through linkage **142** with cam **143** and essentially identical to jaw release track **94**.

As the stop **48** drops out of engagement with the abutment **107**, the capstan **128** operates to advance the gripper carriage **68** to the second indexable stop **47**, whereupon the capstan **128** decelerates and dwells as the abutment **107** is pressured against the indexable stop **47**. During this second dwell period, linkage **144**, driven by face cam **146**, moves clamp **147** to hold the strip material **11** against movement. The linkage **129** is then driven by cam **130** to rock the release track **94** to an upward position to open the gripper jaws **69**, **71**, whereupon the capstan **128** returns the gripper carriage **68** to a start position and pressures the gripper carriage bar **148** against the machine stop **149**. While the capstan **128** is returning the gripper carriage **68**, the cam **150** actuates a shearing blade **151** through the linkage **152**.

The shearing blade, pivotally mounted on the machine frame at **153**, is aligned by guide **154** and the back surface of forming mandrel **114**. As the bent lamination is severed, the rake-off arm **29** drops from the position shown in FIG. 1 to move the severed lamination onto the indexing conveyor as shown in FIG. 7. While the rake-off arm **29** is moving the last of a set of laminations onto the indexing conveyor **31**, and before the gripper carriage **68** advances, the strip material thickness gauging apparatus illustrated in FIG. 2 is used to index shaft **44** and adjust the position of indexable stops **47**, **48**.

Since it is desirable to drive abutment **107** into the indexable stops **47**, **48** with essentially the same pressure of engagement in each cycle of the machine, the drive train for capstan **128** is continually adjustable.

The drive for capstan **128** is derived from cams **155**, **156** which are designed to accelerate and decelerate the capstan **128** between dwells. Adjustment of the drive train between cams **155**, **156** and capstan **128** is accomplished by changing the position of drive pins **157**, **158** in slots **159**, **160** to change the effective crank length of drive arms **161**, **162**. Vertical channels **163**, **164** are guided on horizontal guide ways **165**, **166** and are useful for changing the rocking motion of drive arms **161**, **162** to a straight line reciprocating motion. Trunnions **167**, **168** carry the drive pins **157**, **158** and are positioned in the channels **163**, **164** by vertically adjustable cradles **169**, **170**.

As can be seen in FIG. 7, the cams **155**, **156** are keyed to the main drive shaft **171** of the machine **10**. It will be understood, however, that due to the different configuration of the cam surfaces of these two cams, the movement of drive arms **161**, **162** are in phase with each other only during preselected times in each cycle. The cam drive action includes a first drive interval, a second drive interval, and a return interval. These three intervals correspond to the advance of the gripper carriage **68** to indexable stop **48**, the advance of the gripper carriage to indexable stop **47**, and the return of the gripper carriage **68** to an initial position against machine stop **149**. During the first drive interval, the shaft **172** of capstan **128** undergoes pure rotation to feed the steel band **98** in the direction indicated by the arrow I. The rotation of capstan **128** is affected by the linear movement of horizontal gear rack **173** in the direction of the arrow K. During the second interval of motion, the bearings (not shown) which support the capstan shaft **172** for rotation are translated horizontally in the direction of arrows L by the action of the pushrod **174** while the horizontal gear rack **173** is held stationary.

Since the rack **173** does not move while the shaft **172** and pinion **176** are being translated in the direction L, the pinion **126** rolls along the rack **173**. Thus, the steel band **98** is paid off by the capstan **128** in the direction of the arrow I during the second drive interval due to the accumulative effect of translating and rotating pinion **176** and capstan **128**. It will be understood that during the first drive interval, the drive action for horizontal rack **173** is derived only from the drive pin **157** and that during the second drive interval drive action is derived from drive pin **158**.

In the exemplification, both drive arms **161** and **162** dwell for a short period of time immediately following

the second drive interval, whereupon both drive arms are returned to their initial positions. The return of both drive arms **161, 162** results in a fast return of the capstan **128** to its original position.

As the positions of the indexable stops **47, 48** are changed during operation, the cradles **169, 170** are moved so that the drive action of capstan **128** is adjusted a corresponding amount. Thus, as the indexable stop **48** is moved by lead screw **177** in a direction to foreshorten the first and second feed distances of the gripper carriage **68**, the horizontal rack **178** is moved a corresponding distance. Through the gearing **179–184** the horizontal movement of rack **178** is transformed to a vertical movement of the trunnion positioning cradles **169, 170**. It will be understood that the camming surface **186** has a greater pitch than camming surface **187** on lead screw **177**, and that the gear ratio of pinions **179** and **182** is selected accordingly.

As the cradles **169, 170** reduce the effective radius of drive arms **161, 162**, the first and second drive velocities will be reduced a proportional amount. In order to maintain the average feed rate of the strip material **11** through the machine **10** at an optimum feed rate, provision is made to increase the operating speed of the main drive motor **188**. Accordingly, the rheostat **189** of a conventional D.C. motor speed control **190** is mechanically driven from the pinion shaft **191** to increase the speed of motor **188** in proportion to the reduction of effective drive arm radius. With this arrangement, it will now be seen that we have provided an adjustable drive for the gripper carriage **68** which will reduce the stroke of the carriage but maintain the carriage velocity substantially uniform regardless of the size of laminations being made by the machine **10**.

It is important that the machine **10** produce sufficient laminations prior to recycling that the final build or thickness of the core section **38** indicated by the dimension X in FIG. 4 approximate a nominal design value. Therefore, we have included a data storage mechanism that essentially continually sums the thicknesses of the laminations produced for each core **38**. When the total thickness of laminations approximately equals the predetermined core build dimension X the machine recycles; apron conveyor **40** indexes a step while table **34** dumps core sections **36** onto the apron conveyor **40**, and the laminations of the next succeeding core are produced.

The movement of the build bar **193**, removably carried on stop block **141**, performs the summing function. When the carriage **38** is resting against machine stop **149**, the distance between build bar **193** and limit switch **192** is proportional to the total thickness of laminations needed to complete a core having a nominal dimension X. In the exemplification, this proportion is 2:1 due to the desired stepped joint core configuration which results from a five increment index of shaft **44** after every fourth set of laminations. Therefore, the distance between the build bar **193** and limit switch **192** should be dimensioned by two stock thicknesses each time the build bar **193** indexes toward the limit switch **192**. During operation, the build bar indexes toward the limit switch **192** one, one, one, and five stock thicknesses relative to the frame of machine **10**. Thus, in order to reduce the distance between the build bar **193** and limit switch **192** two stock thicknesses during each index, the limit switch **192** must move both back and forth relative to the frame of the machine **10**. With operation of the back-off mechanism **195** in FIG. 7, the limit switch **192** backs away from the build bar **193** a distance approximately equal to one stock thickness each time the build bar **193** indexes one stock thickness, but moves toward the build bar **193** an equivalent of three stock thicknesses when the build bar **193** indexes five stock thicknesses.

With reference to FIG. 7, it will be seen that the back-off mechanism **195**, pivotally mounted at **196** and biased by tension spring **197**, rides the stepped surfaces **198–201** of surface cam **202**. The surface cam in turn is driven from shaft **171** through the 6:1 Geneva movement **203** and gear **204** having a 3:8 ratio with respect to the cam **202**. Thus, the cam **202** will index 16 times and complete one revolution, for every sixteen revolutions of the main drive shaft **171**. The floating of limit swtich **192** back and forth insures that the distance between the build bar **193** and limit switch **192** is diminished by two stock thicknesses every index and that the actual core build will approximately equal a nominal value.

When the machine **10** recycles, the indexable stops **47, 48**, and trunnions **167, 168** are returned to their initial positions by rotating lead screw **177** in a reverse direction. One arrangement that has proved to be satisfactory in practice has included a control circuit **206** which is connected to limit switch **192**. Closing of limit switch **192** then results in de-energization of the magnetic clutch **207**, and energization of a return motor and magnetic clutch (not shown) connected to shaft **44** which results in a recycling of the lead screw **177**.

Laminations for a number of different sized cores **38** may be produced with the machine **10**, without requiring the replacement of dies, gears, and other machine elements, the replacement of which is usually required in conventional punch press type machines. When it is desired to produce a different size core with the presently disclosed machine **10**, it is only necessary to establish the initial position of the gripper carriage **68** by the replacement of a gripper carriage bar **148** having an appropriate length and to change the length of the gauge bar comprising the second indexable stop **47**. The build of the core will be determined by the selected length of build bar **193**. The drive train for the gripper carriage can be adjusted by repositioning gripper carriage **68** relative to the steel band **98** and breaking the connections between pinions **180, 183** and vertical gear racks **181, 184** to adjust the position to trunnions **167, 168**.

From the foregoing description, it will be apparent that the present invention makes it possible to readily fabricate laminations for preformed magnetic cores at a maximized feed rate wherein compensation is continually made for the thickness of the strip material used to make the laminations, and core build tolerances are very closely maintained. It will also be apparent that apparatus embodying the present invention can make many different sizes of laminations without requiring extensive tooling changes. Although in the illustrated exemplification of our invention, we have shown and described a core forming machine wherein a strip material thickness gauging station is adapted for manual operation, it will be appreciated that the basic operation performed at the strip material thickness gauging station is adaptable to completely automatic manufacturing techniques. Further, the particular embodiment of our invention, which we 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 we intend by the appended claims to cover all such modifications that fall within the true spirit and scope of the invention.

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

1. A machine for making laminations from strip material for preformed magnetic cores formed of core sections defining a plurality of lamination layers, said machine comprising: a strip material supply means, a forming station including a mandrel and a forming shoe, a gripper carriage for advancing the strip material to the forming station, drive means for driving the gripper carriage, at least a pair of stops for limiting the travel of said gripper carriage to selectively provide preselected lengths of strip material, said forming shoe supported for translational and angular movement relative to said mandrel whereby said forming shoe is actuated with an angular movement to bend at least one of said preselected lengths of strip mate-

rial and said forming shoe is initially disengaged from the strip movement with a translational movement to prevent dragging of said strip material, means for indexing said stops to vary said preselected lengths of strip material for forming successive lamination layers, means responsive to the indexing of said stops for adjusting said drive means thereby to vary the travel and speed of said gripper carriage, means for severing said laminations after said strip material is advanced to provide one other of said preselected lengths, a stacking station and a transfer means for transferring laminations to said stacking station, said transfer means including a lamination positioning conveyor for moving a predetermined number of laminations into a prestacking position for transfer to the stacking station and an ejector for placing said predetermined number of laminations positioned in said prestacking position into stacked relationship at said stacking station to build up core sections, and means for recycling the machine when the laminations for at least one magnetic core of a predetermined stack height are formed.

2. A machine for making laminations from strip material for preformed magnetic cores, said machine comprising: a strip material supply means, a forming station, a strip advancing means for selectively feeding strip material to said forming station in preselected indexed lengths, said strip advancing means including a carriage for holding the strip material, at least a pair of index stops for limiting the travel of the carriage, a driver for imparting to said carriage a preselected mode of travel, and a drive train coupled with said driver, said driver including means for accelerating and decelerating said driver as the strip material is being advanced to impart said preselected mode of travel for different positions of said index stops, shearing means for cutting off the lamination, a stacking station for assembling laminations for a predetermined number of core sections, and means for transferring laminations to said stacking station including a positioning conveyor for arranging the laminations into a prestacking position for transfer to said stacking station, and means for ejecting said laminations from said prestacking position on said positioning conveyor into stacked relationship at said stacking station thereby to progressively build up the stack height of said predetermined number of core sections.

3. The machine set forth in claim 1 wherein said predetermined number of laminations positioned on said positioning conveyor in said prestacking position is equal to the number of core sections to be stacked at said stacking station.

4. Apparatus for making laminations for a preformed magnetic core from strip material, said preformed magnetic core being formed of at least a pair of core sections, said apparatus comprising: a strip material supply means, a forming means including a forming shoe and a mandrel for bending an end portion of the strip material substantially at right angles, shearing means for cutting off the lamination, a strip length feeder, a driver coupled with said feeder for advancing said strip length feeder to selectively supply strip material in preselected indexed lengths to the forming means, a stacking station for assembling the laminations, and means for transferring the laminations to said stacking station, said last mentioned means including a positioning conveyor for moving a preselected number of laminations into a prestacking position for transfer to said stacking station, and means for moving the laminations from said prestacking position into a stacked relationship at said stacking station thereby to build up the core sections.

5. The apparatus set forth in claim 4 wherein said preselected number of laminations positioned in said prestacking position on said positioning conveyor is equal to the number of core sections to be built up at said stacking station.

6. The apparatus set forth in claim 4 wherein said stacking station includes an alignment bar for maintaining the alignment of the laminations being stacked at the stacking station to build up said core sections and said means for moving laminations from said prestacking position on said positioning conveyor includes an ejecting bar for simultaneously ejecting all of said predetermined number of laminations in said prestacking position toward said alignment bar to thereby arrange said laminations in stacked relationship with the other laminations at said stacking station.

7. The apparatus set forth in claim 4 wherein said strip material supply means includes an upstanding loop of strip material for feeding material to said strip length feeder, the height of said loop being maintained within predetermined high and low limits by supplying strip material to said loop when the height of said loop falls below the lower limit and by stopping the supply of strip material to said loop when the height of said loop reaches the upper limit.

8. The apparatus set forth in claim 4 wherein said forming shoe is supported by eccentrically mounted bearings for translational and angular movement relative to said mandrel, said translational movement being imparted to said forming shoe by rotating said eccentric bearing support and said rotational movement being imparted by rotating said forming shoe.

9. The machine set forth in claim 2 wherein said predetermined number of core sections being built up at the stacking station is equal to the number of said laminations arranged in said prestacking position on said positioning conveyor.

10. A method of making L-shaped laminated core sections for a magnetic core, said method comprising the steps of: maintaining an upstanding loop of strip material, intermittently advancing the strip material from said upstanding loop to a forming station and to a severing station to produce a set of laminations having substantially the same size and shape, arranging said set of laminations in a prestacking position, and simultaneously ejecting said laminations from said prestacking position into stacked relation at a stacking station to build up a predetermined number of L-shaped laminated core sections, said predetermined number being equal to the number of laminations in said set arranged in said prestacking positions.

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Dedication

3,513,523.—*Armin F. Mittermaier* and *Lowell M. Mason*, Fort Wayne, Ind. MACHINE AND METHOD FOR FORMING LAMINATIONS FOR MAGNETIC CORES. Patent dated May 26, 1970. Dedication filed Sept. 22, 1971, by the assignee, *General Electric Company*.

Hereby dedicates to the Public the remaining term of said patent.

[*Official Gazette January 4, 1972.*]