

Feb. 13, 1951

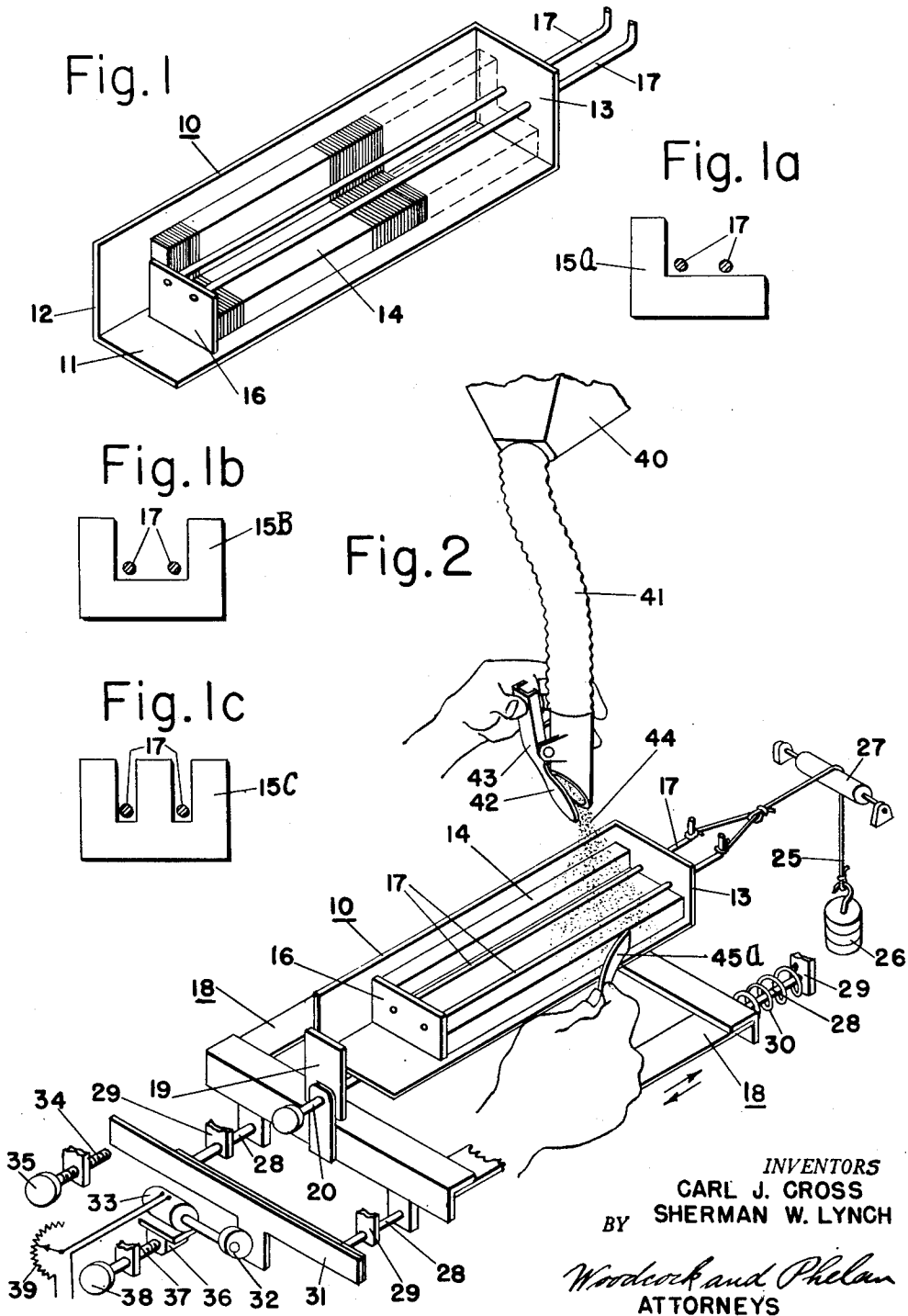
C. J. CROSS ET AL

2,541,502

APPARATUS FOR COATING THIN STIFF SHEETS

Filed June 14, 1948

3 Sheets-Sheet 1



Feb. 13, 1951

C. J. CROSS ET AL

2,541,502

APPARATUS FOR COATING THIN STIFF SHEETS

Filed June 14, 1948

3 Sheets-Sheet 2

Fig. 3a

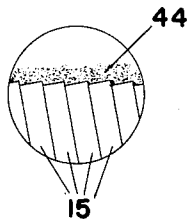


Fig. 3b

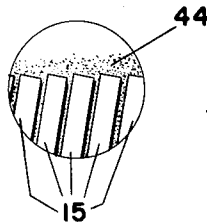


Fig. 4

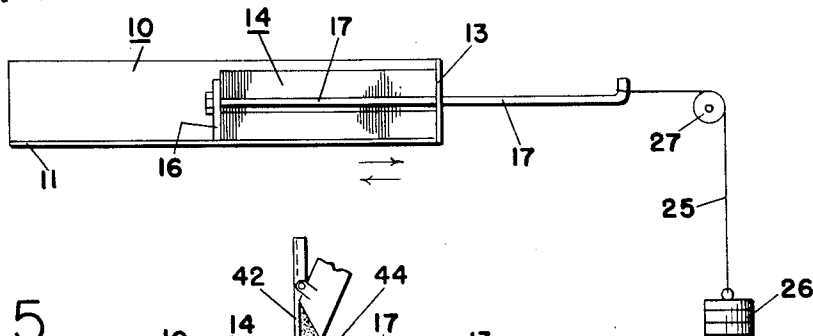


Fig. 5

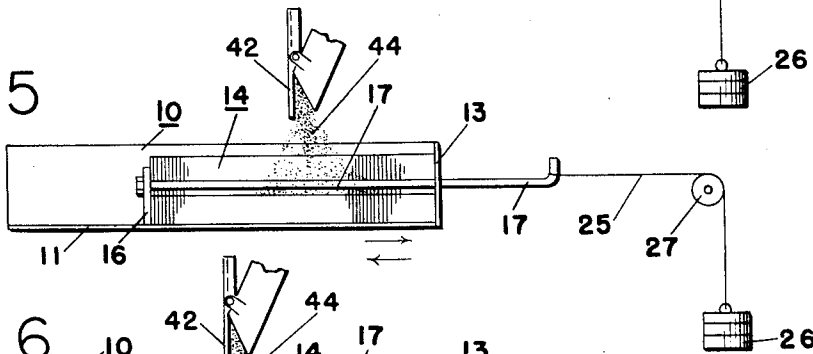


Fig. 6

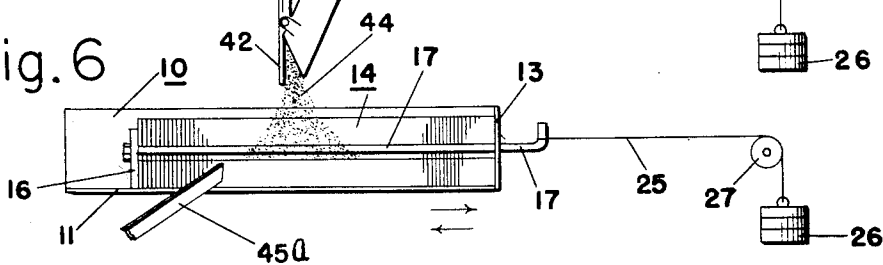
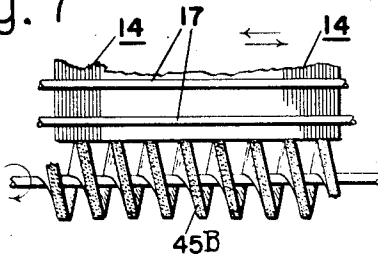


Fig. 7



INVENTORS
CARL J. CROSS
SHERMAN W. LYNCH
BY

Woodcock and Phelan
ATTORNEYS

Feb. 13, 1951

C. J. CROSS ET AL

2,541,502

APPARATUS FOR COATING THIN STIFF SHEETS

Filed June 14, 1948

3 Sheets-Sheet 3

Fig. 8

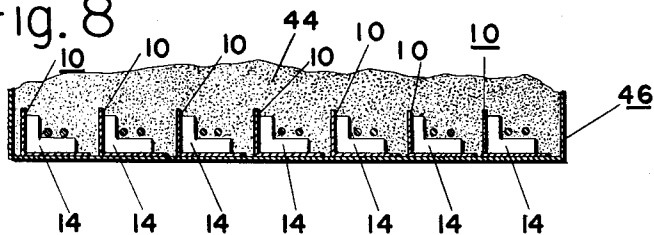


Fig. 9

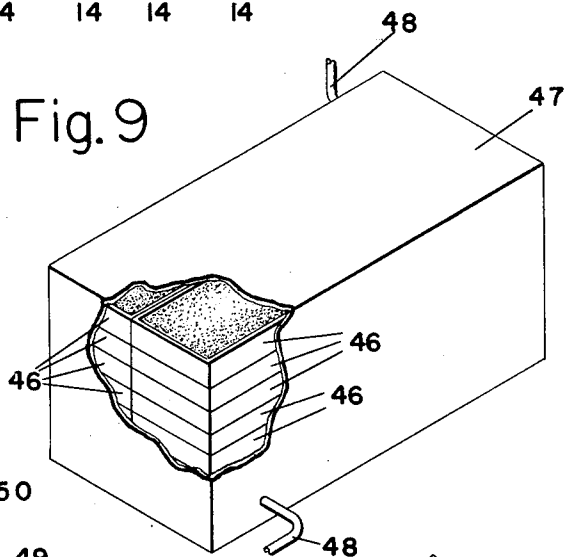


Fig. 10

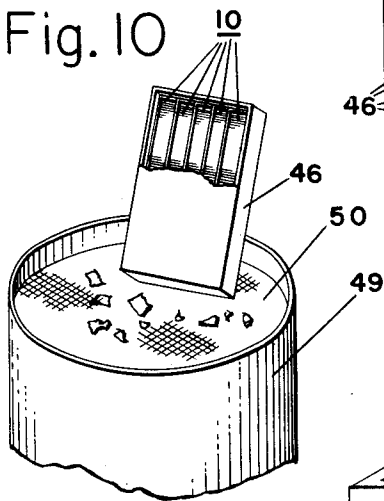
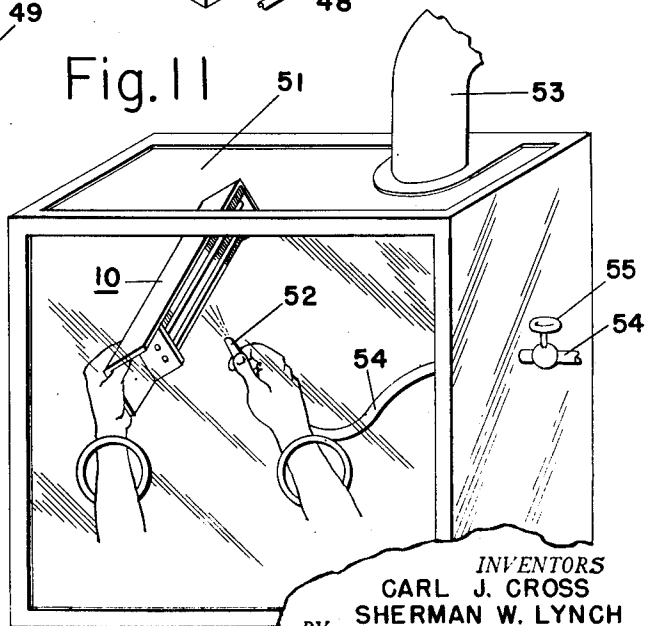


Fig. 11



INVENTORS
CARL J. CROSS
SHERMAN W. LYNCH

BY

Woodcock and Phelan
ATTORNEYS

UNITED STATES PATENT OFFICE

2,541,502

APPARATUS FOR COATING THIN STIFF SHEETS

Carl J. Cross, Runnemede, N. J., and Sherman W. Lynch, Beverly, Mass., assignors to Magnetic Metals Company, Camden, N. J., a corporation of New Jersey

Application June 14, 1948, Serial No. 32,874

6 Claims. (Cl. 91—18)

1

This invention relates to systems for coating thin stiff sheets of any dense material and particularly relates to the coating of thin metal laminations.

In the manufacture of laminations for the cores of electromagnetic devices, such as transformers, filter coils, and the like, used in communication or power circuits, it is usual, after completion of machining operations, to anneal the laminations for attainment or restoration of desired magnetic properties. It is a purpose of the invention to reduce the time and cost of coating the individual core laminations with material which prevents them from sticking together when stacked and subjected to annealing temperature.

In accordance with the invention, the laminations while retained in stacked formation by force applied lengthwise of the stack are subjected to vibration longitudinally of the stack so that the individual laminations due to their inertia rapidly and repeatedly separate slightly so as to permit coating material to flow between them into contact with their adjacent faces. More specifically, the laminations are stacked in a work-holder having a slidable member biased as by a weight against an end of the stack and the holder is attached to a vibratory frame, or equivalent, whose amplitude and frequency of vibration are preferably variable to adapt the apparatus to the inertia characteristics of different stacks and/or to the flow characteristics of different coating materials.

Though primarily devised for coating magnetic core laminations with inert powdered material for prevention of their sticking together during annealing, the apparatus is suitable for application of other coating materials to laminations having other purposes.

The invention further resides in systems having features hereinafter described and claimed.

For a more detailed understanding of the invention, reference is made to the accompanying drawings in which:

Fig. 1 is a perspective view of a work-holder for a stack of laminations;

Figs. 1a, 1b and 1c illustrate the relation of structure of Fig. 1 to laminations of different shape;

Fig. 2 is a schematic perspective view of an apparatus suited to perform the preferred method of coating;

Figs. 3a and 3b are explanatory figures referred to in discussion of movement of the individual laminations of the stack of Figs. 2 and 4 to 6;

2

Figs. 4, 5 and 6 are explanatory figures illustrating lengthening of the stack during the coating operation;

Fig. 7 is a partial plan view of a modification of Fig. 2;

Fig. 8 is a sectional view of an annealing tray containing a plurality of stacks of laminations;

Fig. 9 is a perspective view, partly broken away, of an annealing box containing a plurality of the trays of Fig. 8;

Fig. 10 is a perspective view, referred to in discussion of recovery of the coating material; and

Fig. 11 is a perspective view showing cleaning of an annealed stack.

As briefly mentioned above, before disposition of a stack of laminations in an annealing furnace, they are coated or covered with inert material which affords access of a de-oxidizing or inert gas to the surface of the laminations and also maintains the laminations out of physical contact with each other. Heretofore the step of coating the laminations has been a slow, manually-performed operation which particularly in the case of the smaller laminations, such as are used in the small transformers and inductors used in midget radios, hearing-aids and the like, represented an unduly large and variable factor in the cost of the laminations. By recourse to apparatus herein described, the expense incurred in this preliminary step of the annealing operation is very materially reduced and can be quite accurately predicted for successive runs of similar laminations.

Referring to Fig. 1, the holder 10 preferably comprises a bottom wall 11, a side wall 12 and an end wall 13, all preferably permanently secured to one another to form a trough or receptacle in which a stack 14 of laminations may be disposed. One end of the stack engages the fixed wall 13 of the holder 10 and the other end of the stack is engaged by a slidable member or end wall 16 which is pressed or held against it so to retain the individual laminations in place. The bars 17, or equivalent, overlie the stack to prevent the laminations from being dislodged in handling of the holder by an operator or during the various operations subsequently described. In the preferred construction shown, the rods or bars 17 are attached to the slidable member 16 and freely pass through and beyond the end wall 13.

When the laminations are L-shaped, as are laminations 15A of Figs. 1 and 1a, one leg of the laminations is disposed adjacent the side wall 12 of the holder and the other leg of the laminations rests upon the bottom 11. Thus, as apparent

from Figs. 1 and 1a, the rods 17, or equivalent, cooperate with the bottom and side walls of the holder to retain the laminations in place.

When the laminations are U-shaped, as are laminations 15B of Fig. 1b, the rods 17 are disposed between the two vertical legs of the laminations and cooperate with the bottom of the holder 10 to retain the laminations in place. With U-shaped laminations, it is not necessary that the holder have a side wall 12 but to enable the same holder to be used for various shapes of laminations, the construction shown is preferred.

When the laminations are E-shaped, Fig. 1c, the rods 17 are respectively disposed between the central vertical leg and the two outside legs and so cooperate with the bottom wall 11 of holder 10 to retain the laminations 15C in place. Again, for this shape of lamination it is not necessary for the holder to have a side wall 12.

The holder 10 is preferably of the open construction shown to facilitate loading and unloading and to afford ready escape of excess coating material but it shall be understood the holder may have a second side wall and/or a second fixed end wall.

For laminations of widely differing size, it may be necessary to use work holders of correspondingly different dimensions but with the type construction shown, only a small number of work-holders is necessary to accommodate a substantial range of sizes and shapes.

After a stack of laminations has been disposed in a holder 10, the holder is secured to a vibratory frame 18 which, as shown in Fig. 2, may have a jaw 19 operable by a clamping screw 20 rigidly to attach a holder 10 to the frame 11. It shall be understood that the holder 10 may be an integral part of the frame 18, but it is desirable to have the work-holder detachable from the frame 11. Among other advantages, this permits the loading of one holder with laminations while another holder is being vibrated for coating of the laminations therein; it also permits the same vibratory frame 18 to be used with different holders respectively suited for laminations of widely different sizes and shapes.

After the holder 10 is attached to the vibratory frame 18, the projecting ends of the rods 17 are attached, as by cord 25, to a counterweight 26, or equivalent, which supplies a biasing force tending to compress the stack 14 between the fixed end-wall 13 of the holder and the slidable end-wall 16, or equivalent. The pulley 27, or equivalent, is provided so that the downwardly acting force of counterweight 26 may be converted to a force acting lengthwise of the stack. For reasons which will hereinafter appear, it is desirable to use a weight instead of a spring to insure, throughout the coating operation, substantial constancy of the biasing force applied to the stack. It shall be understood, however, that biasing force may be and preferably is different for stacks of differently dimensioned laminations and, accordingly, the counterweight 26 is composed of individual weights which may be added or removed to accommodate the different inertia characteristics of the different stacks.

In the particular arrangement shown in Fig. 2, the vibratory frame 18 is mounted upon a pair of rods 28 which are slidable in the stationary frame members 29 of the machine. The frame 18 is biased as by springs 30 for movement in one direction. The cross member 31 connected to the rods 28 or to any other part of the vibra-

tory frame assembly is engaged by a cam or eccentric 32 driven by electric motor 33 or any other suitable driving means. The amplitude of vibration of frame 18 may be regulated in any desired manner; in the particular arrangement shown by way of example, the stop 34 is adjusted by hand-wheel 35 to limit the extent to which the frame 18 may be moved in one direction by the biasing spring 30 and the extent to which the frame 18 may be moved in the other direction by the cam 32, or equivalent, is or may be varied by shifting the position of the motor support 36 which threadably engages a screw 37 rotatable by the hand-wheel 38. In any event, whether by the particular means shown or by other equivalent means, it is desirable to provide for a variable amplitude of vibration of the frame 18 to obtain optimum results with stacks of different sizes, weight and other characteristics.

It is also desirable that the frequency of vibration of frame 18 be controllable to suit the apparatus to different stack loads. In the particular arrangement shown in Fig. 2, this is conveniently effected by provision of a rheostat 39 in circuit with the motor 33. It shall, of course, be understood that other regulating means suited for the particular chosen type of motor may be used and that the rheostat 39 is generically illustrative of any speed control means for varying the frequency of vibration of frame 18.

A coating material commonly used to protect core laminations during annealing is aluminum oxide although oxides of magnesium, calcium, barium and the like have been used for this purpose. Other materials such as diatomaceous earths have also been used. In general, these coating materials are chemically inert and extremely fine, for example, of the order of 400 mesh, or finer, so that they are free-flowing.

To supply such coating material to the region in which the stack 14 is being vibrated, there may be provided a hopper 40 terminating in a discharge pipe or spout 41 having at its lower end a valve 42 provided with a handle or lever 43 actuable by the operator who during the vibration of the stack may move the end of the spout 41 back and forth to distribute the coating material along the upper face of the stack.

During vibration of the stack, the individual laminations rock about their lower edges, Figs. 3a and 3b, and consequently when there is provided the proper relations between the inertia of the stack and the biasing force applied by plate 16, the upper edges of the individual laminations repeatedly and rapidly separate to allow progressive, intermittent flow between them of the coating material 44 piled on the top of the stack. Preferably, during vibration of the stack, the operator runs a riffling tool 45A, such as a flat flexible spring member, along the exposed side edge of the stack to facilitate the flow of coating material to the lower edges of the laminations; otherwise the interposed coating material might tend to form a wedge between adjacent lamination faces instead of a sheet of substantially uniform thickness. Alternatively, and as shown in Fig. 7, this riffling of the side or lower edges of the stack may be performed automatically, as by a rotating, spiral brush 45B mounted adjacent the stack. With very thin laminations, it may be desirable to use a skeleton holder which in part exposes the other side of the laminations and/or the bottom edges.

During vibration of the stack, the coating ma-

terial progressively flows down between the laminations and the stack, accordingly, grows or lengthens as exemplified by Figs. 4 to 6. Even with inexperienced operators, there can readily be obtained a coating between the individual laminations which is quite uniform in thickness throughout the length of the stack. As indicative of the growth of a stack because of the interposed coating material, a stack which originally may be only, for example $3\frac{1}{2}$ or 6 inches long, may be as long as $10\frac{1}{2}$ inches within a very short time. The extent to which a stack grows during the coating step depends, of course, upon the number of laminations in the stack, the usual lamination thickness being of the order of from 0.006 to 0.014 inch.

The time required to obtain coating of the many hundreds of laminations in a stack is of the order of only half a minute, which is many times shorter than the time required for hand-stacking: the differential, of course, varies with the size and number of laminations in the stack, with the individual operators, and is the greater, the smaller the size of the laminations: on an average, the time is reduced by a factor of about 10.

Moreover, with the apparatus described, the time required for coating of a stack of a given number of pieces and a given size is about the same for different operators, whereas with hand-stacking, the time varied widely for different operators and for the same operator with different size of laminations.

Use of the apparatus is not limited to the coating of core laminations with aluminum oxide or other protective material. It may, for example, be used to coat laminations with a powdered binding agent, such as powdered thermoplastics, or thermosetting resins, Bakelite, or the like. In such case, the stack after coating is heated while compressed to fusing temperature of the binder which, upon cooling, permanently holds the laminations together to form the core assembly of a transformer, choke, or the like, avoiding need for rivets, clamping bolts or the like. Reverting to discussion of the coating as preliminary to annealing: when the laminations have between them a coating of desired thickness, the holder is removed from the carriage 11, the operator by hand maintaining pressure against the end plate 16 to maintain the stack formation of the laminations. A plurality of such holders with coated stacks are disposed in an annealing tray 46, Fig. 8, which is then filled with more of the powdered material 44 completely to cover the stacks. A plurality of such loaded trays are then disposed in an annealing box 47, Fig. 9, which is preferably shut to form a gas-tight enclosure for the trays. The box 47, or usually several of them, are then disposed in an annealing furnace and raised to annealing temperature preferably during flow through the box 47 of hydrogen or other gas which is de-oxidizing or inert. The inlet and outlet pipes 48-49 at the opposite ends of the box are provided for flow of such gas.

At the end of the annealing operation, the trays are removed and the protective material, now caked or hardened, is removed. Preferably as shown in Fig. 10, the material 44 is recovered for future use by collection in a receptacle 49 provided with a screen 50. The individual work-holders are then removed from tray 46 and the remaining material blown off by an air blast. As shown in Fig. 11, the operator while grasping

the work-holder 10 in one hand, lightly presses against the slidable end wall 16 to retain the laminations in stack formation, and with the other hand directs a blast of air from the nozzle 52 against the laminations. The air blast ruffles the loose laminations and blows out from between them the remainder of the powdered coating material. Preferably and as shown in Fig. 11, this operation is performed in a closed chamber 51 provided with an exhaust duct 53 to prevent the fine powder from being inhaled by the operator. Air under suitable high pressure is supplied to the nozzle 52 through a pipe 54 having a shut-off valve 55.

Thus, throughout the entire sequence of operations from Figs. 1 to 11, the laminations are retained in one and the same work-holder and are transferred from one stage of operation to the next as a unit, the rods 17, or their equivalent, cooperating with the fixed and slidable walls of the holder to retain the laminations in stack formation and prevent their dislodgment during handling.

Use of the apparatus described is not limited to coating of core laminations: it is suited for coating of stiff sheets of metal or non-metals. It is not suited for coating of sheets which are of such material, or are so thin compared to their width, that they flex substantially during vibration.

In general, the apparatus is suited for sheets whose thickness is from about .005 inch to about .015 inch and whose stiffness factor, which is proportional to the moment of inertia of the cross sectional shape of the lamination and inversely proportional to the cube of the length of the lamination, is within the range of from about 0.5×10^{-9} to about 15×10^{-9} . The relation of its stiffness factor to the dimensions of the laminations may be expressed as:

$$K = \frac{wt^3}{12l^3}$$

where

K=stiffness factor

w=width of lamination cross section

t=thickness of lamination

l=length of lamination

The coating materials suited for application to stacked laminations by the method described are generally free-flowing dry powders of fineness suitable to pass through a screen of the order of 400 mesh or finer.

What is claimed is:

1. Apparatus for coating stiff, flat laminations comprising holder structure for loosely retaining the laminations on their lower edges in stack formation, means for vibrating said holder structure in direction substantially normal to the plane of each of said laminations, and means for supplying coating material to the upper edges of the stacked laminations while held in said vibrated structure whereby said coating material flows between and coats said stacked laminations as they rock about their lower edges in said vibrated structure.

2. Apparatus for coating stiff, flat laminations comprising a frame, means for vibrating said frame, a work-holder for loosely retaining the laminations on their lower edges in stack formation, means for detachably attaching said work-holder to said frame, and means for supplying coating material to the upper edges of the stacked laminations whereby said material flows between

7

and coats said stacked laminations as they rock about their lower edges in the vibrated workholder.

3. Apparatus for supporting stiff, flat laminations in a region supplied with coating material comprising a holder having a movable end wall, means for biasing said movable end wall against a stack of laminations resting on their lower edges in said holder to retain them in stack formation, and means for vibrating said holder in direction longitudinally of the stack intermittently to overcome the biasing force by the inertia of the laminations whereby said laminations rock about their lower edges and repeatedly slightly separate at their upper edges to receive said coating material for flow between them.

4. Apparatus for supporting stiff, flat laminations in a region supplied with coating material comprising a holder having a slidable end wall, biasing means exerting pressure through said slidable end wall upon a stack of laminations resting on their lower edges in said holder with their upper edges disposed to receive said coating material, means for vibrating said holder in direction longitudinally of the stack whereby the inertia of the laminations intermittently overcomes said pressure for rocking of said laminations about their lower edges, and means for controlling the amplitude and frequency of the vibration of said holder to suit said apparatus for stacks of different characteristics including weight and size.

5. Apparatus for coating laminations comprising a holder for laminations resting on their lower edges in stack formation, a slidable end wall within said holder for engaging an end of the stack, means comprising rod structure attached to said slidable end wall and overlying the stacked laminations to confine them in said holder, said rod structure in part projecting exteriorly of said holder, a biasing weight connected to the projecting part of said rod structure, means for vibrating said holder rapidly to rock the laminations about their lower edges, the inertia of the

8

vibrated laminations intermittently overcoming the biasing force of said weight whereby the upper edges of said laminations repeatedly slightly separate, and means including a discharge pipe above said holder for supplying coating material to the upper edges of the stacked laminations for flow between them during vibration of said holder.

6. Apparatus for supporting magnetic core laminations in a region supplied with powder of nature protecting them during annealing comprising holder structure for loosely retaining therein a stack of said laminations resting on their lower edges, biasing means for applying to the stack a compressive force retaining the laminations in stack formation with their upper edges positioned to receive said powder, a frame to which said holder structure is detachably held, and means for vibrating said frame in direction longitudinally of the stack whereby the inertia of the laminations intermittently overcomes said compressive force, said laminations rocking about their lower edges and repeatedly slightly separating at their upper edges to receive said protective powder for flow between them.

CARL J. CROSS.
SHERMAN W. LYNCH.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
805,095	Ridd	Nov. 21, 1905
1,354,061	Palmer	Sept. 28, 1920
1,482,607	Gow	Feb. 5, 1924
1,666,044	Danziger	Apr. 10, 1928
1,782,536	Kirschbraun	Nov. 25, 1930
1,838,701	Nicolai	Dec. 29, 1931
2,163,642	Wallach	June 27, 1939
2,187,617	Fogg	Jan. 16, 1940
2,247,794	Wallach	July 1, 1941
2,412,954	Zdancewicz	Dec. 24, 1946