

Sept. 6, 1949.

H. V. KNAUF, JR
COIL WINDING MACHINE

2,481,314

Original Filed July 31, 1946

4 Sheets-Sheet 1

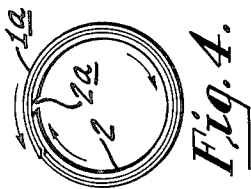


Fig. 4.



Fig. 7.

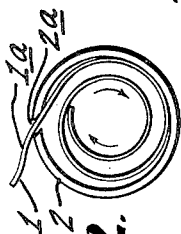


Fig. 2.

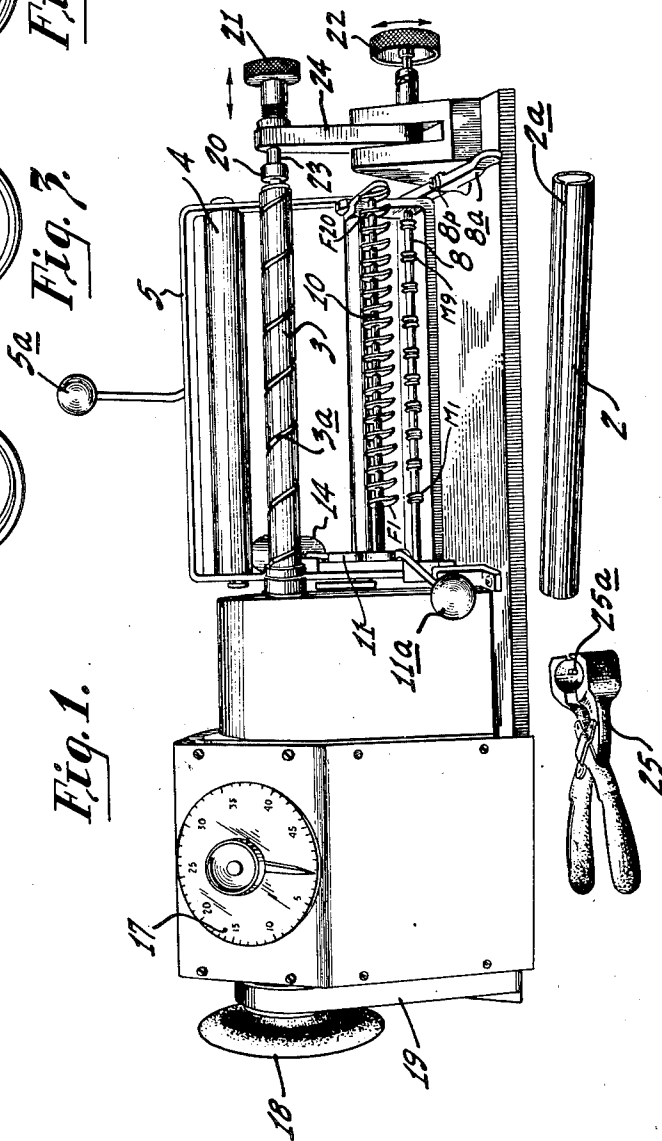


Fig. 1.

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Fig. 5.

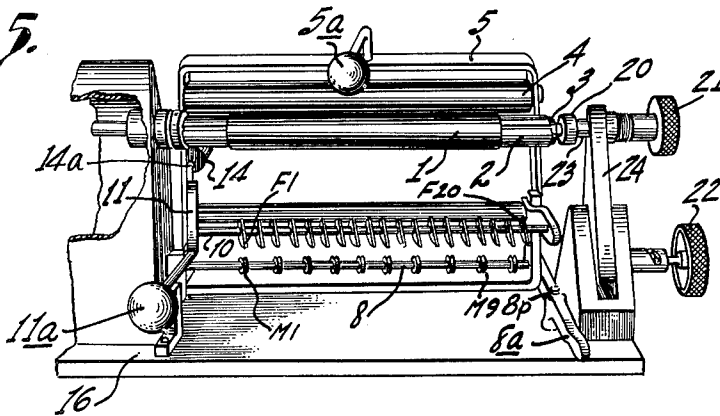


Fig. 6.

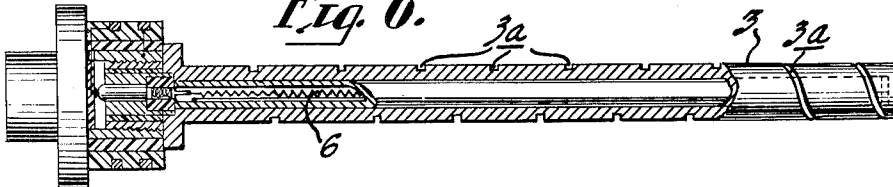
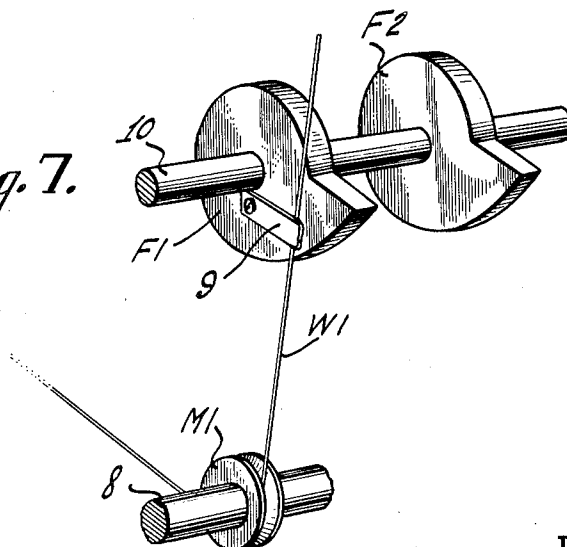


Fig. 7.



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Fig. 9.

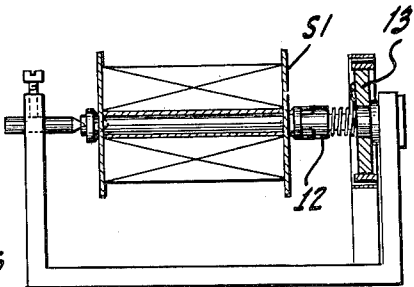
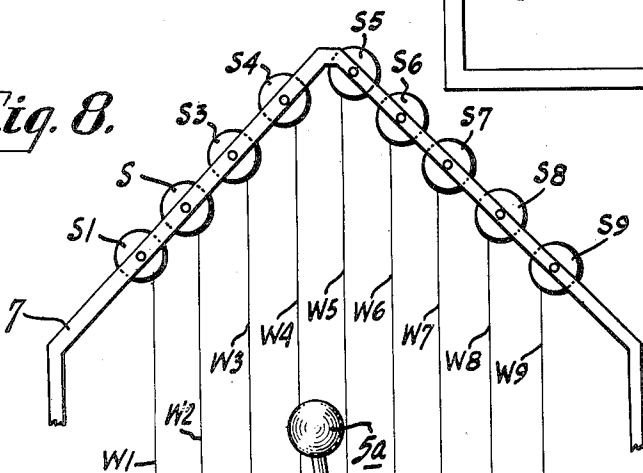
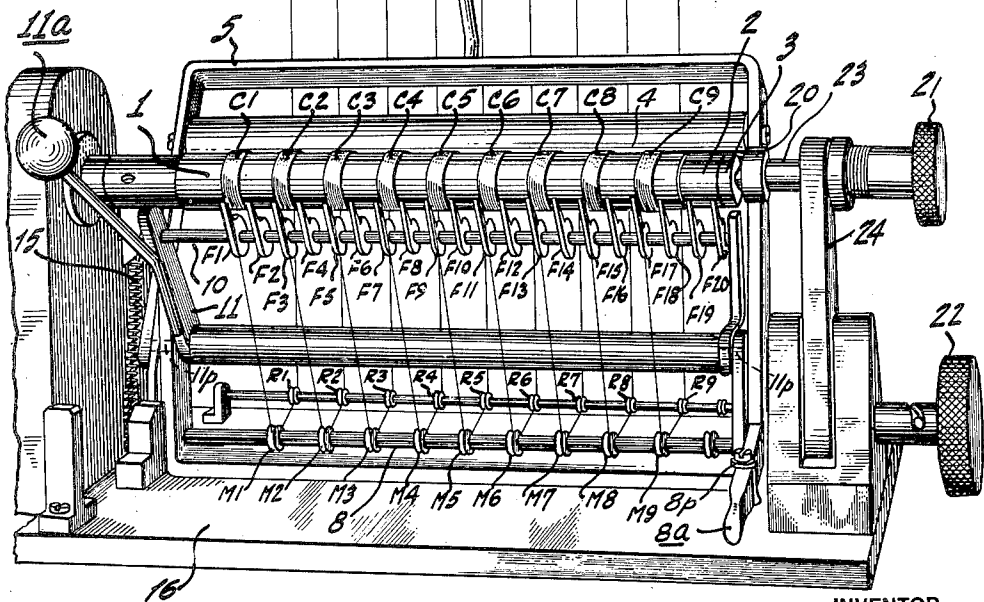


Fig. 8.



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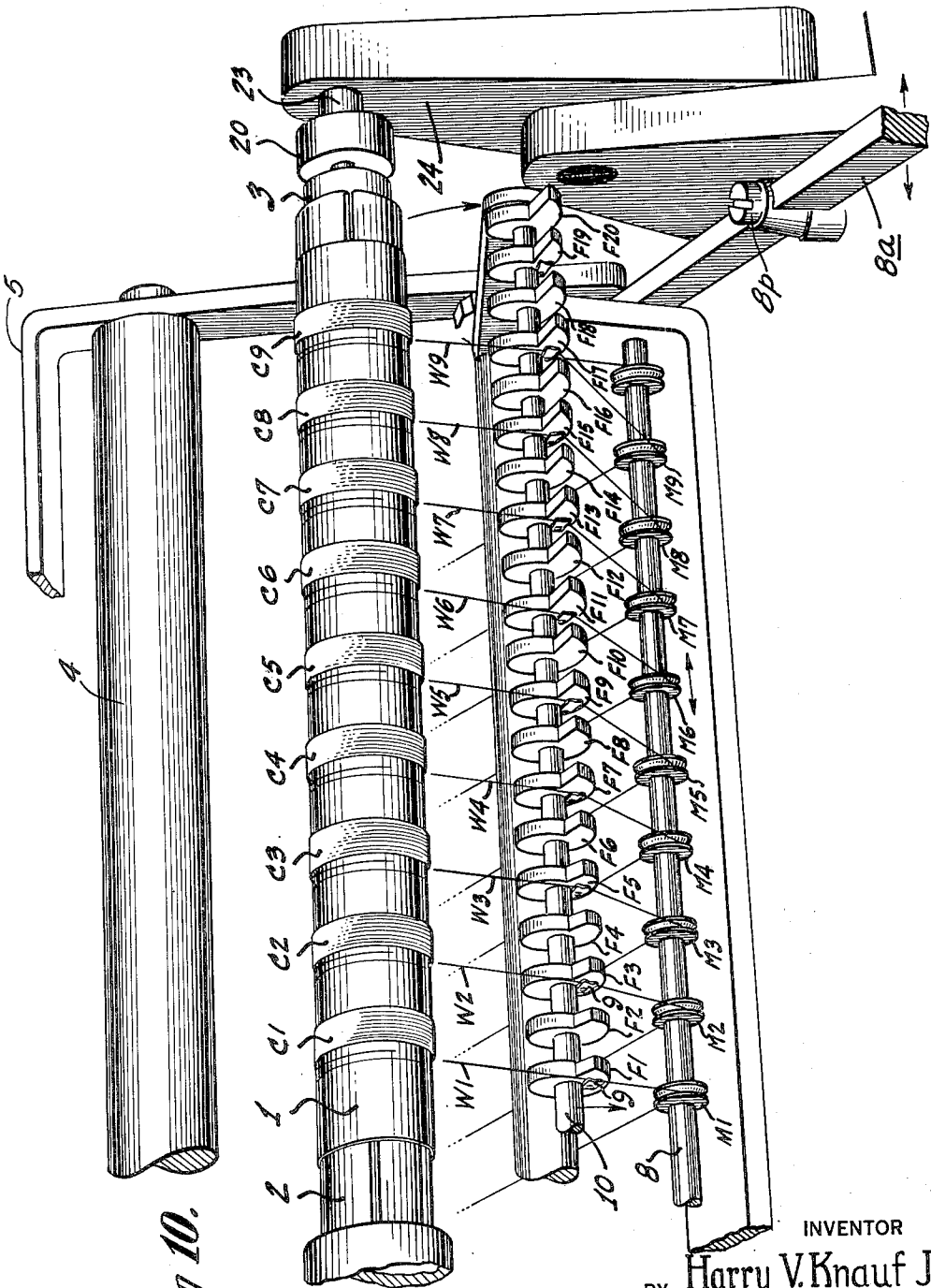


Fig 10.

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UNITED STATES PATENT OFFICE

2,481,314

COIL-WINDING MACHINE

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Original application July 31, 1946, Serial No.
687,447. Divided and this application Septem-
ber 27, 1946, Serial No. 699,617

3 Claims. (Cl. 242-9)

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This case is a division of copending application
Serial No. 687,447 filed July 31, 1946.

This invention relates to the art of winding
coils, particularly to improvements in machines
for making form-mounted inductance coils and,
while not limited thereto, will be described as
applied to the manufacture of "voice coils" for
loudspeakers.

Loudspeaker voice coils usually comprise either
a single or plural layer helix wound upon a cy-
lindrical impregnated-paper form which is no
thicker than, say, 0.005 of an inch. When made
by mass production methods such coils have here-
tofore been "wet-wound," i. e. the adhesive im-
pregnant which binds the wire and the coil form
into a unitary structure is applied in a highly
fluid state during the winding operation and is
subsequently evaporated, as in a drying oven.
Wet-winding is an untidy procedure and is an ex-
pensive one as well. Furthermore, wet-winding
results in an unusually high percentage of re-
jects. Why this is so will be apparent when it is
appreciated that since the bonding agent must
be applied in an extremely fluid condition it can
contain only a small percentage of solid adhesive
material, hence the strength of the bond between
the parts is relatively poor even in those units
which are thoroughly dry and otherwise perfect.
Thorough drying is not always achieved in prac-
tice because a wet-wound coil immediately ac-
quires a surface skin which traps the liquid sol-
vent and renders its escape difficult even under
accelerated drying conditions. Incompletely dried
coils may retain the trapped solvent for many
months and when such a coil is subject to nor-
mal vibrational stresses (i. e., in the audio fre-
quency range of from, say, 30 to say, 10,000 cycles
per second) its turns may "creep" and ruin the
performance of the loudspeaker. Prolonged dry-
ing, on the other hand, may cause the coil form to
shrink and the coil to warp, making it necessary
to expand the form in an effort to restore the
assembly to its original shape and dimensions.

Accordingly, the principal object of the present
invention is to obviate the foregoing and other
less apparent objections to present day wet-
wound coils and to provide an improved appara-
tus for winding voice coils and analogous (form-
mounted) inductors.

Another and related object of the invention is
to provide an improved apparatus for the dry-
winding and embedment of coils and one which,
in its use, dispenses with all auxiliary moulding
and other shaping mechanisms. (Cf. the 1924
British Patent No. 250,282 to Rickets et al.)

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The foregoing objects are achieved in accord-
ance with the method of the parent invention,
first by making, on a mandrel or arbor, a coil-
form having a dry coating of a synthetic resinous
thermosetting adhesive material in an interme-
diate stage of fusibility on its outer surface, then
heating the coating material (as by heating the
arbor) to render said coating tacky, then wind-
ing wire having a similar (dry) adhesive coating
on the said form whereby the coating on the wire
is rendered tacky by contact with the heated sur-
face of the coil-form, and then heat-setting both
coatings to the infusible stage.

Certain preferred details of procedure and con-
struction, together with other objects and advan-
tages of the invention will be described in con-
nection with the accompanying drawings where-
in:

Fig. 1 is a view in perspective of a multiple coil
winding machine constructed in accordance with
the principle of the invention and including a
detached cylindrical split-sleeve for making a coil
form and a tool for removing said sleeve from the
heated mandrel of the machine.

Figs. 2, 3 and 4 are end views of the split sleeve
of Fig. 1 showing the manner in which the sheet
material, of which the coil form is made, is
wrapped.

Fig. 5 is a fragmentary view in perspective of
the machine of Fig. 1 showing the sleeve of Figs.
1 to 4 on the heated mandrel and undergoing a
rolling operation for bonding the layers of sheet
material together.

Fig. 6 is a longitudinal sectional view revealing
the construction of the heated mandrel of the
machine.

Fig. 7 is an enlarged view in perspective of one
of the wire-guiding and holding means of the
machine.

Fig. 8 is a view in perspective showing the wind-
ing machine in operation and including the reel-
ing system from which the wires are fed to the
coil form.

Fig. 9 is an enlarged side elevational view partly
in section of one of the supply reels of Fig. 8, and

Fig. 10 is an enlarged fragmentary view in
perspective of the machine upon the completion
of the winding movement, with the wires broken
off and held in a position to permit the removal
of the coil form from the mandrel.

In applying the invention to the manufacture
of voice coils, it is preferable to start with a high
grade kraft paper, say, 0.006 to 0.0015 of an inch
thick, and with enamel covered copper wire, of
the desired gauge, and coat the paper and the

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wire, separately, with the thermosetting adhesive material which is allowed to dry at room temperatures to a point where all of its volatile constituents have evaporated. Any of numerous resinous adhesives having the property of becoming tacky at an elevated temperature which is lower than is required to "set," or render it infusible, may be employed as the coating material. In general, all "A-stage" condensation type thermosetting resins possess this desired characteristic. The adhesive properties of the coating material may be enhanced by the addition of a thermoplastic adhesive such, for example, as a vinyl resin. One satisfactory coating material formula is:

Part A

	Grams
Gelva No. 60 (vinyl acetate resin)-----	200
One step phenolic resin-----	200
Acetone (solvent)-----	1000

Part B

	Grams
Vinylite XYSG (vinyl acetal resin)-----	150
One step phenolic resin-----	150
Ethyl alcohol (solvent)-----	1200

By "one step phenolic resin" is meant a phenolic resin in that incomplete stage of condensation (commonly known as the "A stage") wherein the resin is still fusible and completely soluble. (When parts A and B of this formula are mixed there is a tendency to separate, thus the material should be agitated during the coating process.) Other, ready-mixed, thermosetting adhesives are available under various grade marks.

The dry adhesive-coated paper 1 from which the coil forms are made tends, usually, to curl up on its coated side 1a. Since the adhesive must be on the outside of the finished form it is necessary or expedient to counteract this tendency, either by tension (e. g. by running it over a smooth, warm surface and then wrapping it on a cylindrical form) or by curling the sheet in the reverse direction, as by inserting it in the slot 2a of a split metal sleeve 2 and then withdrawing it and wrapping it on the outside of the sleeve, in the manner indicated by the curved arrows in Figs. 2, 3 and 4. With the paper thus wound on the metal sleeve 2 its turns may be prevented from unwinding before the sleeve is placed on the coil winding machine by heating the coated surface at spaced points along its edge. This "spot tacking" operation can be done simply by touching the wrapped paper to the electrically heated mandrel or arbor 3 of the winding machine.

The machine shown in the drawings is especially constructed for the commercial practice of the invention and is provided with a rubber or similar roller 4 which is mounted on a pivoted bracket or frame 5 parallel to the arbor 3 so that the roller may be brought into contact with the rolled paper when the sleeve 2 upon which the paper 1 is wrapped is mounted on the electrically heated rotating arbor 3. The heat transferred through the sleeve 2 to the paper from the electrical heater element 6 (see Fig. 6) is just sufficient to soften the adhesive coating on the paper. Thus, when the handle 5a on the bracket 5 is pulled down (as shown in Fig. 5), the roller 4 is brought into contact with the paper and applies a rolling force which bonds the tacky layers of the paper together into a smooth, composite cylindrical structure. When the rolling operation is completed the roller 4 is thrown back and the tacky paper is ready to receive the wire or wires.

Any number of coils within the limits of the

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length of the winding arbor 3 may be wound simultaneously. As shown in Fig. 8 the machine is set up to wind nine coils. Here the nine supply spools S1—S9 are supported in equally spaced relation on a triangular frame 7 above and to the rear of the arbor 3 and the individual wires W1—W9 are led down around fixed rollers R1—R9 and thence forward and upward over grooved guide members M1—M9 on a rod 8 which is mounted for axial movement, parallel to the axis of the arbor 3, under the control of a hand lever 8a which can be moved to the left and to the right on a pivot 8p on the base of the machine. In setting up the wires W1—W9, prior to the winding operation, the free end of each wire is held upright each by a spring clip 9 (see Fig. 7) on the outer face of the alternate (odd-numbered) of ten pairs of wire guiding "fingers" F1 to F20 which are mounted beneath the arbor 3 on a movable support comprising a rod 10 which is secured at its opposite ends to the arms of a U-shape bracket or frame 11. This frame 11 is carried on pivots 11p at the base of the U and is provided with a hand lever 11a. As shown in Fig. 9 the axle of each supply spool S1 etc. is provided with a clutch 12 to facilitate replacement of the spool and with a friction brake 13 for maintaining tension on the wire throughout the winding operation.

After the coil form has been rolled and the roller 4 moved out of the way, each wire is removed from its clip 9 and placed on the tacky surface of the coil form slightly to the left of the odd-number finger, to provide an extra length of wire which when removed from the coil form comprises an attaching lead for the coil. As soon as the wires are brought into contact with the heated surface of the coil form they are held fast by the tacky adhesive thereon. The operator then raises the handle 11a of the pivoted bracket or "lever means" 11 and thus brings the wire guiding fingers F1—F20 on the rod 10 adjacent to, but not touching, the rotatable heated arbor 3 upon which the sleeve 2 for coil form 1 is mounted. The fingers F1 etc. are maintained in the raised position, shown in Fig. 8, by means of a counter-weight 14 carried on an arm 14a (see Fig. 5) on the rear of the pivoted bracket 11, and an over-center spring 15 (see Fig. 8) which is secured at one end to the rod 10 and, at its other end, to the base 16 of the machine. The lever 8a is then moved to the right. This shifts the axially movable rod 8 upon which the grooved wire guides M1 etc. are secured, to the left, and brings the said guides into the starting position.

When all wire ends have been removed from the clips 9 and applied to the coil form 1, and the lever 11a has been raised, the arbor 3 is rotated through as many revolutions as required to form a coil of the desired number of turns. As shown in Fig. 1 the power required to rotate the arbor 3, and to operate its conventional revolution counter 17 may be applied either by means of a hand-wheel 18 or by a belt 19. In the latter case the belt may be driven by an electric motor not shown) under control of a foot actuated switch (not shown).

The limits of the length of the individual coils C1, C2, etc. are determined by the spacing of the paired fingers F1—F2, F2—F3, etc. As previously set forth, the rod 8 upon which the grooved wire guides M1 etc. are mounted can be moved axially with respect to the fingers F1 etc. and the arbor 3, under the control of the lever or arm 8a. Hence, when winding a voice coil or similar

plural layer structure, it is merely necessary to move the pivoted arm 8a on its pivot 8p to the left at the time the wire comprising the lower layer reaches the side of the even-number fingers (F2, F4, etc.) in order to start the second or reverse-wound layer. This movement of the arm 8a to the left moves the rod 8, which carries the grooved wire-guides M1 etc., to the right. Obviously, the spacing of the turns comprising either layer may be regulated, if desired, by changing the rate of movement of the lever 8a as by means of a cam (not shown). In this latter event it is preferable to mount the rod 8 somewhat closer to the arbor than is shown in the drawings.

In Fig. 8, the rod 8 has reached the limit of its movement in the return (left) direction. That is to say, the wires W1—W2 etc. have reached their starting point adjacent to the faces of the odd-numbered fingers F1, F3, etc., and the winding operation has been completed. While the bar 10 is still in its raised position the operator pulls each wire over the end of the adjacent (odd-numbered) finger F1, F3, etc., and, by so doing, places it under the spring clip 9 on the said finger, and then severs all of the wires, simultaneously, simply by pulling down the handle 11a of the pivoted supporting frame 11 against the biasing force of the counterweight 14 and off-center spring 15 (Fig. 8). In pulling down the handle 11a the operator may hold the handwheel 18 (Fig. 1) against rotation. This however, is not always necessary since the several turns of the coils, provide a "snubbing action" which is usually sufficient to prevent the arbor 3 from turning when the handle 11a is pulled down. As shown in Fig. 10, the arc of movement of the rod 10 upon which the guide fingers F1, etc. are mounted is such that, when the U-shape frame 11 is pulled down, the free-end of the wires W1, W2, etc. are held in a readily accessible upright position and the coil ends of the wires are conveniently "tacked" to the adhesive on the coil form 1 by the force applied to the wires during the severing operation.

In order to remove the sleeve 2 upon which the coil form 1 is mounted from the arbor 3 it is first necessary to release the bearing 20 at the outer end of the arbor. This is done by turning two thumbscrews 21 and 22. The upper screw 21 releases the shaft 23 upon which the said bearing is mounted and the lower screw 22 releases the upright 24 which supports the said shaft, thus permitting the said support 24 to be pivoted towards the rear, out of the way of the arbor 3. When the metal sleeve 2, upon which the paper coil form is mounted, has a tight fit on the arbor 3, its removal from the arbor is facilitated by using the pincer-like tool 25 shown in Fig. 1. One of the cylindrical jaws of this tool contains an inwardly extending pin 25a which is adapted to be received within a helical groove 3a in the arbor. Thus, when the jaws of the tool are closed about the inner end of the arbor and the arbor is rotated (as by means of the hand-wheel 18) the pin 25a will follow the groove 3a and urge the sleeve 2 outwardly toward and off the free end of the arbor.

When, as shown in the drawings, the metal form upon which the paper and coils are wound

comprises a "split" sleeve, the diameter of the said form will be effectively reduced upon its removal from the arbor 2. This obviously facilitates the removal of the paper coil-form from the said sleeve. However, since it is desirable to mount the still tacky paper-form 1 on a metal form during the thermosetting of the adhesive, it is usually expedient to employ a conventional (non-split) cylindrical form throughout the winding operation, since, in this event, the same form may be used during the setting process. In any event, when the winding operation has been completed, the paper form 1, mounted on its temporary inner cylindrical metal support, is subject to a temperature higher than that used during the winding operation in order to set the resinous adhesive coatings on the paper and wire. A conventional oven (not shown) may be used for this purpose. Thereafter the paper coil form may be cut into discrete lengths each individual to a single coil.

It will now be apparent that the present invention provides an improved apparatus for "dry-winding" form-mounted coils and, furthermore one which provides a coil structure that will retain its shape throughout the assembly operation and is substantially immune to vibration, humidity and temperature changes.

What is claimed is:

1. In a coil winding machine, a rotatable arbor, a movable support, a pair of wire guides mounted on said movable support in spaced array along a line parallel to the axis of rotation of said arbor, said wire guides having opposed faces between which a wire is adapted to pass in its journey to said arbor, a wire clamp mounted on the outer face of one of said guides in a position to receive said wire when said wire is placed therein upon completion of a winding interval, and lever means for moving said support and hence said wire guides and said clamp away from said mandrel with sufficient force to sever said clamped wire at a point intermediate said clamp and said arbor.

2. The invention as set forth in claim 1 and wherein said movable support is pivotally mounted at the front of said machine and is adapted to be moved by said lever means in the reverse direction through an arc calculated to bring the severed end of the unwound portion of said wire in a position closely adjacent to said arbor.

3. In a coil winding machine, a rotatable arbor adapted to receive a sleeve about which a sheet having a dry outer surface coating of a heat responsive adhesive is wrapped to form layers, means for heating said arbor whereby to render said coating tacky, a support adapted to be moved toward and away from said rotatable arbor, a roller mounted on said support for rotation in contact with the sheet when said support is in said first mentioned position whereby adjacent faces of said layer-wrapped sheet are bonded together by said adhesive into a composite cylindrical coil form having a tacky outer surface, and means to rotate said heated arbor to wind a wire upon said tacky outer surface of said cylindrical coil form.

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No references cited.