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3,021,092

TAPERED SPOOL

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2 Sheets-Sheet 1

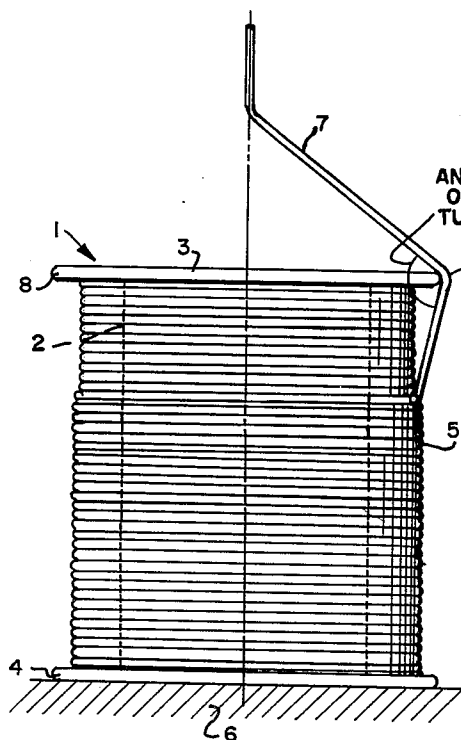


Fig-1

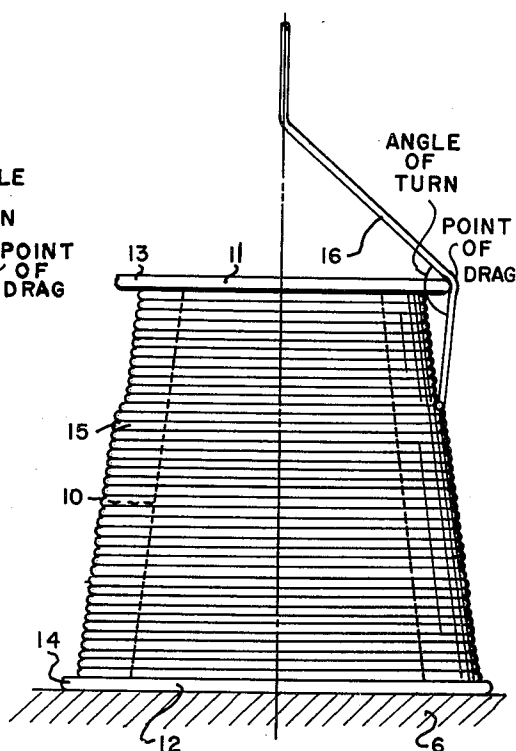


Fig-2

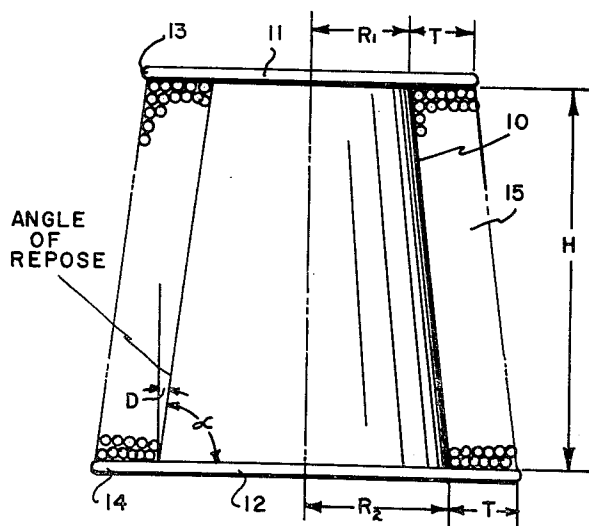


Fig-4

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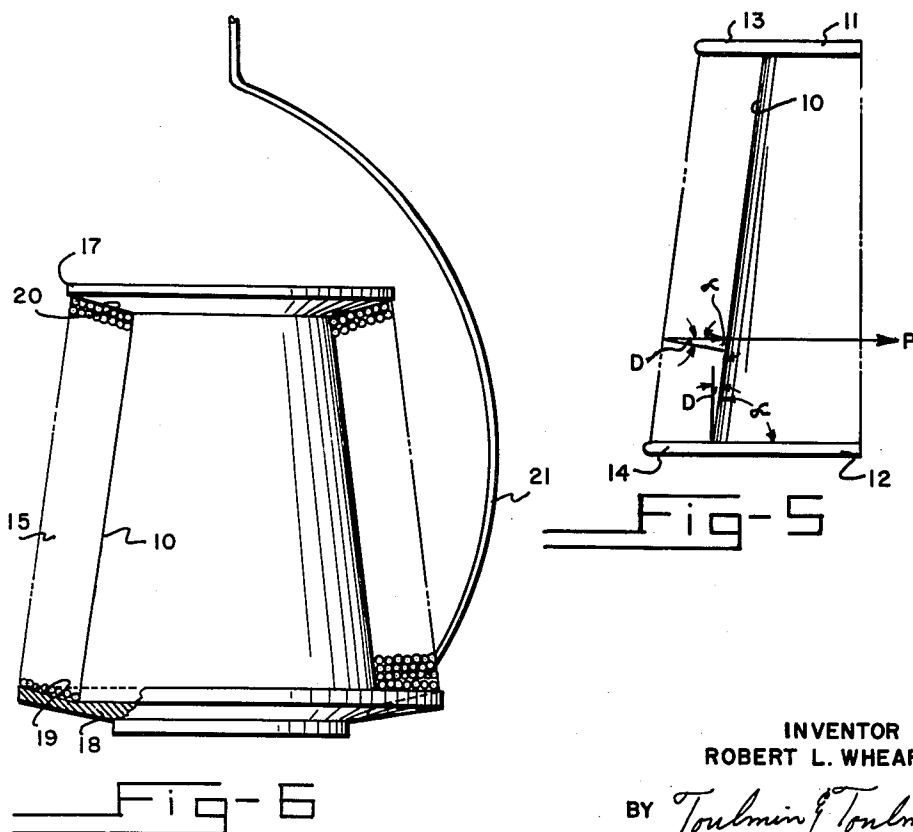
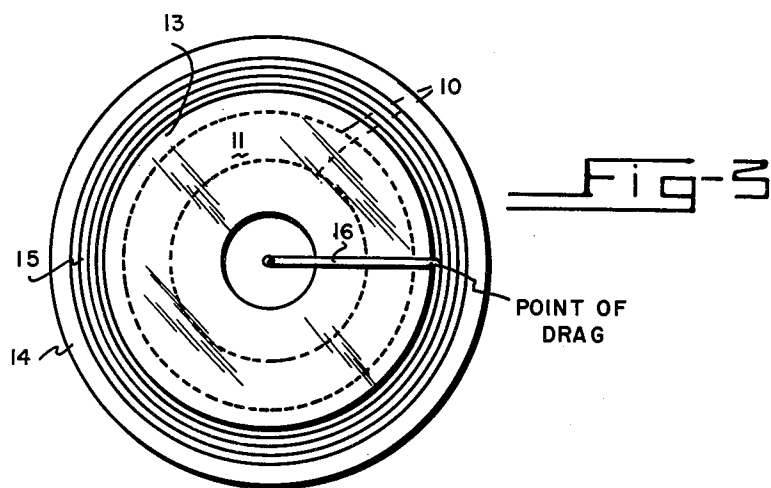
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TAPERED SPOOL

Robert L. Whearley, Fort Wayne, Ind., assignor, by mesne assignments, to Rea Magnet Wire Company, Inc., Fort Wayne, Ind., a corporation of Delaware
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3 Claims. (Cl. 242-123)

The invention relates to a novel spool which is adapted for the retaining of wire, particularly magnet wire.

Reels and spools for the shipping of magnet wire have been customarily made with a cylindrical body and opposed parallel flanges. The magnet wire, which is an electrically insulated wire and very generally of small diameter, is deposited on the spools in uniform layers by the wire manufacturer. Shipment is then made on these spools to the user, such as a coil manufacturer. Spools normally carry 30 to 40 pounds of the magnet wire.

While many devices have been designed to aid the user of the magnet wire in de-reeling, it is still preferred by such consumers to simply set the spool in a stationary position, as on a floor, and with the major spool axis vertical, to merely pull the wire from the spool.

The pulling of the wire is in an axial and vertical direction, the wire unwinding itself from the spool in the process. In thus unwinding the wire must come out from under the upper flange and turn sharply and the wire accordingly rubs against the flange and around the flange periphery. As more of the wire is unreel, and as it is unreel closer to the upper flange, the more acute is the angular turn of the wire and the greater the drag of the wire on the flange.

Magnet wire may have different types of insulation, such as enamel, resins, cotton coverings and so forth, and these insulating materials are exposed to wear as the wire is subjected to heavy drag on the flange when the wire is turned at a sharp angle. Further, danger of wire breakage exists in such de-reeling operations.

A primary object of this invention is to provide a spool of novel structural arrangement from which the dispensing of wire may be effected in the manner described but while minimizing to a material extent the drag of the wire and the angle of turn of the wire as it is de-reel, features which also lead to greater speed in de-reeling.

A particular object of the invention is the provision of a spool of novel structural arrangement in which a large percentage of a body of wire wound on the spool lies outside of the periphery of the upper flange or cap plate of the spool and substantially does not drag on the cap plate as the wire is removed.

An important object of the invention is the provision of a spool or reel having a tapered wire-carrying body provided at its upper end with a cap plate of relatively small dimension but which extends beyond the tapered body a distance substantially equal to that which a larger supporting base plate extends beyond the tapered body, to thus provide for a uniform thickness of wire over the length of the tapered body.

A further object of the invention is the provision of a novel method of winding and withdrawing wire from a reel, the withdrawing action being effected while the reel is stationary.

In the practice of the invention then the spool on which the shipped wire is wound is provided with a tapered body which suitably is of cone-shape, although a body which is curvilinear over the length thereof and tapers outwardly from the upper flange to the lower flange is suitable. Thus a surface of revolution having a profile equation of a circle, or of circular segment, is useful. The tapered body is supported on a base plate which extends beyond

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the inclined surface of the body a predetermined distance. The other small end of the tapered body is provided with a cap plate of such a dimension that it extends beyond the tapered body a distance substantially equal to that of the extension of the base plate. The wire is wound on the tapered body, and between the cap plate and base plate, such that the radial dimension or thickness of the wire winding is substantially a constant from the cap plate to the base plate.

With such a spool arrangement a large percentage of the wire lies beyond the outer periphery of the smaller diameter cap plate and the wire may be drawn from the spool in the direction of the cap plate axially of the spool without substantial rubbing action on the cap plate.

Reference will be made in detail hereinafter to a cone-shaped body since such exemplifies an important embodiment of the invention.

To inhibit slippage of the innermost layer of wire on a cone-shaped body as the winding is formed the lateral cone angle must not be greater than the angle of repose although it may be somewhat less. In accordance with the invention the lateral cone angle however should be as large as practical for it has been found that as the lateral cone angle decreases below the angle of repose a lesser amount of the wire of the winding will lie outside of the periphery of the cap flange.

The angle of repose is dependent particularly on the coefficient of friction and is somewhat variable with the material of the tapered body and the insulation on the wire. Such coefficient for materials commonly employed has been found by experiment to lie between 0.1 and 0.175. As to lateral cone angle satisfactory results have been attained when the complement of the lateral cone angle is at as low as $5^{\circ}21'$; slippage tended to occur at about $10^{\circ}2'$ utilizing the same materials. Generally the spool is formed of wood, or metal such as aluminum, and the above coefficients apply to such materials when the winding is with magnet wire as noted hereinbefore. The coefficient is of significance only with respect to the first layer of wire applied to the tapered body since thereafter the insulation will be wound upon itself and slippage is then not a serious factor as friction is somewhat greater.

The windings may be applied in any conventional fashion and winding around the spool perpendicular to the longitudinal axis of the spool is satisfactory as described hereinafter.

Approximately 50% of the wire of the winding may be provided outside of the periphery of the cap plate; the periphery of this cap plate or upper flange will not then interfere with wire withdrawal and speed of withdrawal may therefore be greater.

The invention will be more fully understood by reference to the following detailed description and accompanying drawings wherein:

FIGURE 1 is an elevational view of a conventional spool having a cylindrical body and flanges of equal diameter, the figure showing magnet wire being withdrawn axially from the spool and forming a sharp angle of turn as it passes the point of drag on the upper spool flange;

FIGURE 2 is a similar view of a spool formed with a body of conical shape and depicting a much smaller angle of turn than shown in FIGURE 1, the wire being withdrawn from the spool at substantially the same height on the spool as in FIGURE 1;

FIGURE 3 is a top plan view of the structure of FIGURE 2;

FIGURE 4 is an elevational and somewhat schematic view illustrating the dimensional relationships of the spool of FIGURE 2;

FIGURE 5 is a force diagram illustrating the forces

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acting and their angular relationships on a first layer of wire applied to the spool; and

FIGURE 6 is an elevational view illustrating a further embodiment of the invention.

Referring to the drawings and initially to FIGURE 1 the numeral 1 designates a spool of the prior art having a cylindrical aluminum body 2, an upper flange 3, and a lower flange 4 of the same diameter as the upper flange. A body of magnet wire 5, such as enameled wire for example, is shown wound on the spool perpendicularly to the spool longitudinal axis.

As shown the spool is set firmly upon a foundation such as a flooring 6 and wire is being withdrawn as a strand 7 axially from the spool; it is customary to so de-reel the wire to pass the wire to coil winding machines (not shown). The wire as it is withdrawn drags over the outer periphery 8 of flange 3 and forms a sharp angle of turn with itself. This angle of turn increases materially as the wire is withdrawn from a position closer to the upper flange and beneath the flange. Such sharp angle formation with itself tends to injure the wire as does the dragging of the insulation across the flange.

In the embodiment of the invention shown in FIGURE 2 the angle of turn is materially decreased and substantially no drag will be applied to the wire as the wire is withdrawn from lower portions of the spool where a primary portion of the wire length is positioned. This is more fully illustrated by the embodiment shown in FIGURE 6, to which more detailed reference will be made hereinafter.

In the structure of FIGURE 2 the spool body 10 is of conical shape and is provided with a cap plate or upper flange 11 and a base plate or lower flange 12. The numeral 13 designates the outer periphery of cap plate 11 and the numeral 14 indicates the outer periphery of the base plate 12.

The body of magnet wire 15 is provided on the spool body 10 with the wire running substantially perpendicularly to the spool axis. As shown a strand 16 being withdrawn axially from the spool has an angle of turn which is less sharp than the angle of turn shown in connection with the conventional structure of FIGURE 1. Further as the wire unwinds down the spool in the same outer layer the angle of turn will become less sharp and will in fact substantially be 0° or 180°—that is the wire will not be bent materially but will flare outwardly as particularly illustrated in FIGURE 6. Further the drag will decrease as the wire unwinds in the outer layer from the FIGURE 1 position.

It is to be particularly noted that the thickness of the winding of wire 15 is uniform over the height of the spool and that the extensions of the cap plate 11 and base plate 12 beyond the body 10 are equal to provide for such uniformity in the winding thickness.

It is to be noted that the wire tension as the wire is applied to the spool is an important factor, particularly with respect to the application of the first layer of wire to the spool. Reference is made to FIGURES 3 and 4 for a consideration of the relationships between optimum cone angle, wire volume, wire tension and particularly the volume of wire which lies outside of the cap plate periphery.

In FIGURE 4 R1 designates the radius of the body of conical shape at its upper end, while R2 designates the radius of the body of the conical shape at its lower end. T in FIGURE 4 indicates the extent to which the cap plate and base plate project beyond the body of conical shape. Also the letter α designates the angle of repose, while the complement of this angle α is designated D.

Referring to FIGURE 4, the volume of the frustum of a cone is—

$$V = \frac{1}{3} (A_1 + A_2 + \sqrt{A_1 A_2}) h$$

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where A_1 and A_2 are the areas of the bases and h is the height; and t is the plate projection.

The volume of wire on the cone is:

$$V_w = h/3 [(R_2 + t)^2 \pi + (R_1 + t)^2 \pi + \pi (R_2 + t)(R_1 + t)] - h/3 (R_1^2 \pi + R_2^2 \pi + \pi R_1 R_2) \quad (2)$$

$$V_w = \frac{\pi h}{3} [(R_2 + t)^2 + (R_1 + t)^2 + (R_2 + t)(R_1 + t) - R_2^2 - R_1^2 - R_1 R_2] \quad (2)$$

also

$$\tan \alpha = \frac{h}{R_2 - R_1} \quad (3)$$

$$R_1 = R_2 - \frac{h}{\tan \alpha} \quad (4)$$

Volume outside of flange:

$$V_o = \frac{\pi h}{3} [(R_2 + t)^2 + (R_1 + t)^2 + (R_2 + t)(R_1 + t)] - \pi h (R_1 + t)^2 \quad (5)$$

The angle α may be determined from the maximum pull which may be applied to the wire as the first layer is wound on the reel without slippage.

It is to be noted that the wire is customarily applied to the reel under considerable tension. The forces acting in the application of the wire as the wire is applied perpendicularly to the axis of the cone are illustrated in FIGURE 5.

Referring to FIGURE 5, the pull of the wire, P has two components, one in the direction of the cone taper which tends to slide the wire off the cone and has the magnitude $P \cos \alpha$ and one, perpendicular to the cone surface which has the magnitude $P \sin \alpha$. The friction force F, opposing the component $P \cos \alpha$ is $P \sin \alpha f$. Equating the two, we have

$$\cot \alpha = f$$

and

$$\alpha = \cot^{-1} f \quad (6)$$

Since the lateral cone angle α is the complement of angle D, Equation 6 may be written

$$D = \tan^{-1} f \quad (7)$$

α is the "angle of repose."

As already noted tests indicate that the friction coefficient lies between 0.1 and 0.175; accordingly a valley for the complement of angle of repose of 7½ degrees may be assigned to the angle D; is then 82½ degrees. Tests indicate that the angle of repose may extend somewhat higher.

As a specific example:

$$2R_2 = 4\frac{3}{8}''$$

$$t = 1''$$

$$h = 6''$$

$$d = 7\frac{1}{2}^\circ$$

$$= 82\frac{1}{2}^\circ$$

Therefore:

$$\tan = 7.5958$$

(from Eq. 3)

$$R_2 - R_1 = 6/7.5958 = 0.795$$

$$R_1 = 2.3125$$

$$\frac{-0.7950}{1.5175}$$

V_w (from Eq. 2) is then:

$$V_w = \pi \frac{\times 6}{3} [(2\frac{3}{8} + 1)^2 + (1.5175 + 1)^2]$$

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$$\begin{aligned}
 &+(2\frac{5}{16}+1) (1.5175+1) - 2\frac{5}{16} \times 1.5175^2 \\
 &- 2\frac{5}{16} \times 1.5175 = \\
 &2\pi \times [11+6.3+8.35-5.30-2.3-3.50] \\
 &= 91.5 \text{ cu. in. This is approximately 30 lbs.}
 \end{aligned}$$

V_o (from Eq. 5)

$$V_o = \frac{\pi \times 6}{3} (11+6.3+8.35) - 6\pi \times 6.3 = 43.5 \text{ cu. in.}$$

It is to be noted that assuming a lateral cone angle of $82\frac{1}{2}$ degrees, which lateral cone angle would be the angle of repose, then $47\frac{1}{2}$ percent by weight of the total volume of wire on the body of conical shape will lie outside of the cap plate.

Investigation of curvilinear tapered bodies indicates that the angle of repose is the determining factor and that such will vary somewhat with the nature of the materials in the spools and the insulating material on the wire.

Referring now to FIGURE 6 the embodiment of the spool shown therein is provided with a conical body 10 but has a cap plate 17 which is provided with an inwardly tapering face fronting on the cone-shaped body as designated at 20. Accordingly the winding 15 lies at a slight angle to the longitudinal axis of the spool. The base plate 18 is then undercut at 19 in the face fronting on the larger end of the spool to provide parallel layers in the winding 15 over the length of the spool. Further as shown in FIGURE 6 when wire is withdrawn in a strand as at 21 from a lower portion of the winding the wire easily passes the periphery of the upper flange.

Speed of withdrawal is increased and elimination of many of the drawbacks of the conventional spool are avoided by the tapered body spool having the above noted characteristics. Important among these characteristics are that the plates retain the wire securely on the spool even though the wire, since it is applied to the spool under tension, has a tendency to expand. Further, substantially the same amount of wire as presently wound on conventional spools may be wound on the spool of invention and the extension or projection of the plates to accomplish this may be predetermined.

The term "spool" as employed in this application is to be understood to include reels; in the trade the term "spool" is generally applied to structures having a 10 inch diameter flange, while the term "reel" is employed for structures having a 12 inch diameter flange or larger.

It will be understood that this invention is susceptible to modification in order to adapt it to different usages and conditions and accordingly it is desired to com-

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prehend such modifications within this invention as may fall within the scope of the appended claims.

What is claimed is:

1. A spool having a central cone-shaped body, a cap plate on the body at the smaller end of the body and projecting peripherally beyond the surface of the body at the smaller end, said cap plate also having a tapered face of cone-shape fronting on the cone-shaped body, a base plate on the opposite and larger end of the cone-shaped body and projecting beyond the said larger end peripherally and beyond the periphery of the cap plate a distance sufficient to provide between the plates and about the cone-shaped body an annular spacing of substantially constant radial dimension over the length of the body, said base plate having a face fronting on the cone-shaped body which is formed in the periphery thereof outwardly of the cone-shaped body to lie parallel to the said face of the cap plate.
2. A spool having a central tapered curvilinear body, a base plate on the body and extending beyond the inclined surface of the tapered body at the larger end of the tapered body, and a cap plate mounted on the other and smaller end of the tapered body, the extension of the plates beyond the tapered body being equal, the faces of the plates fronting on the said tapered body being in parallel relation, and the lateral angle of said tapered body being greater than about 80 degrees and less than about 85 degrees.
3. A spool having a central tapered curvilinear wire-carrying body, a base plate on the body and extending beyond the inclined surface of the tapered body at the larger end of the tapered body, a cap plate mounted on the other and smaller end of the tapered body, the extension of the plates beyond the tapered body being equal, the faces of the plates fronting on the said tapered body being in parallel relation, and an annular body of wire of constant thickness radially supported on the body between the plates so as to have a tapered curvilinear surface substantially corresponding to that of said tapered body, the angle of repose being greater than about 80 degrees and less than about 85 degrees, and with substantially 50 percent by volume of the annular body of wire lying outside the periphery of said cap plate.

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