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H. H. RAYMOND

2,428,093

NONLINEAR VOLTAGE DIVIDER AND METHOD OF MAKING

Filed July 24, 1946

Fig. 2

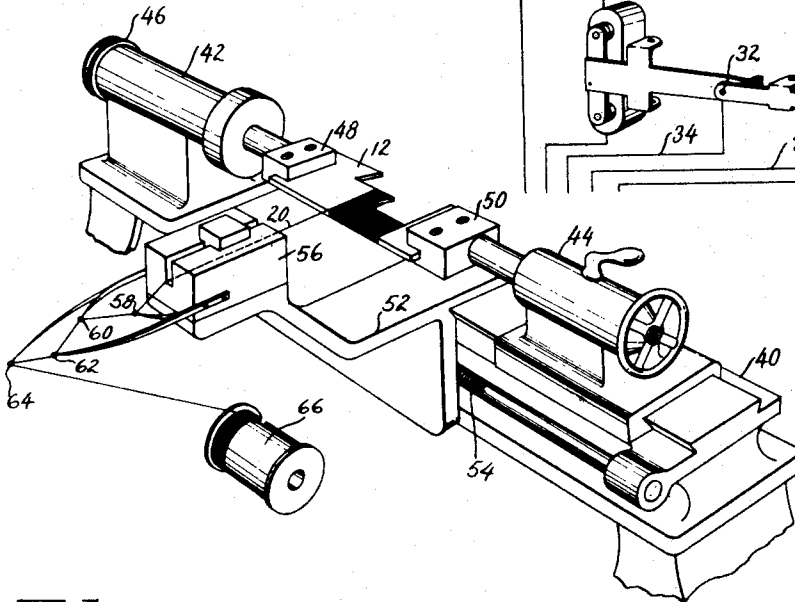


Fig. 1

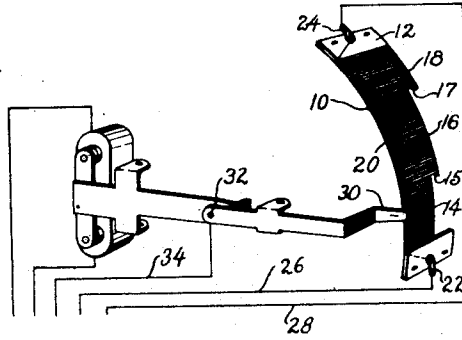


Fig. 3

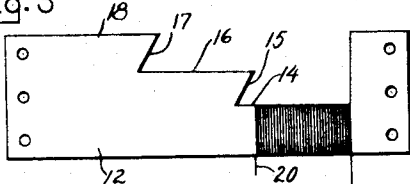


Fig. 4

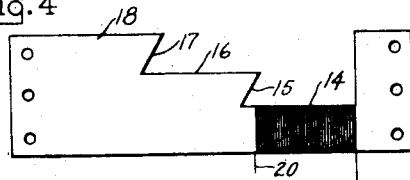


Fig. 5

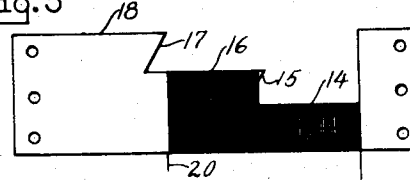


Fig. 6



Fig. 7



Fig. 8

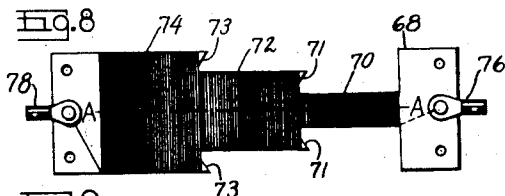
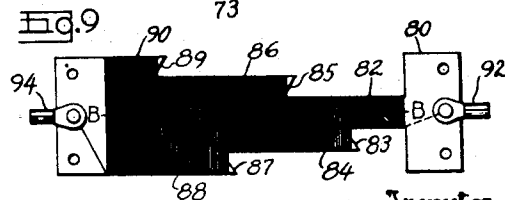


Fig. 9



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Inventor  
HORACE H. RAYMOND  
S. Jay Teller  
Attorney

## UNITED STATES PATENT OFFICE

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NONLINEAR VOLTAGE DIVIDER AND  
METHOD OF MAKING

Horace H. Raymond, Berlin, Conn., assignor to  
Raymond Engineering Laboratory, Inc., Berlin,  
Conn., a corporation of Connecticut

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12 Claims. (Cl. 201-73)

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The invention relates to a voltage divider of the type comprising a continuous series of convolutions of wire wound on a suitable insulating support. Current is passed through the convolutions of wire, there being a progressive diminution of voltage at successive convolutions. Provision is made for traversing an electrical contact over the convolutions along a predetermined line, the voltage at the contact point being thus varied in accordance with the particular convolution that may be engaged. If the convolutions are of the same size from end to end of the series, the voltage variation is directly proportionate to movement of the contact, and if a graph were plotted showing voltage in relation to contact movement, the voltage variation would be represented by a straight line. For some purposes, however, it is desirable or essential for the voltage to vary otherwise than in direct proportion to the contact movement so that if plotted in graph form the voltage variation would be represented by a curved line. A voltage divider of the type last mentioned is designated as a nonlinear voltage divider.

In theory a nonlinear voltage divider can be constructed by providing a support or blank for the convolutions of wire which varies in size or tapers from end to end, the variation in size of the blank or the taper thereof being determined in accordance with the desired variations in voltage with respect to the movement of the movable contact. However, serious practical difficulties are encountered in winding wire on a tapered blank as the wire is not firmly held by the inclined surfaces of the blank and tends to move longitudinally thereof as it is wound.

To avoid this difficulty it has heretofore been proposed to provide a blank having one or more sections of different sizes with steps between them, each section being of uniform size throughout. This provides for a nonlinear variation of voltage and by providing a sufficient number of different sections with a corresponding number of steps, the variations in voltage, while ordinarily not conforming exactly to the theoretical requirements, are sufficiently close thereto for most practical purposes.

However, serious difficulties have been encountered in properly winding a blank having sections of different sizes with steps between them. The principal object of the present invention is to provide a nonlinear voltage divider having a stepped blank wherein the difficulties heretofore encountered are eliminated, and a further object of the invention is to provide a method of

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winding a stepped blank wherein the said difficulties are eliminated.

Further objects of the invention will be apparent from the following specification and from the accompanying drawing.

In the drawing I have shown in detail a preferred embodiment of the mechanical features of the invention and have illustrated a preferred manner of practicing the method of the invention, but it will be understood that various changes may be made from the construction and method shown and that the drawing is not to be construed as defining or limiting the scope of the invention, the claims forming a part of this specification being relied upon for that purpose.

On the drawing,

Fig. 1 is a perspective view, partly schematic, showing a nonlinear voltage divider embodying the invention in conjunction with a movable electric contact cooperating therewith.

Fig. 2 is a perspective view, partly schematic, showing an apparatus that is suitable for practicing the method of the invention.

Figs. 3 to 6 are views showing successive steps in the method of making a nonlinear voltage divider embodying the invention.

Fig. 7 is a perspective view showing a complete nonlinear voltage divider embodying the invention.

Figs. 8 and 9 are views showing alternative nonlinear voltage dividers embodying the invention.

Referring particularly to Fig. 1, 10 represents a nonlinear voltage divider embodying the invention. The voltage divider 10 comprises a blank 12 which is preferably initially flat and which may be formed from compressed fiber or any other suitable insulating material. The blank 12 has a plurality of sections of different sizes or widths, each section being of uniform size or width throughout. As shown, there are three such sections 14, 16 and 18 with steps 15 and 17 between them. The steps 15 and 17 are shown as being at one edge of the blank, the other edge being initially straight. A resistance wire 20 is wound on the three sections 14, 16 and 18 in a continuous series of uniformly spaced convolutions. In referring to uniformly spaced convolutions reference is had to the spacing between the center lines of adjacent convolutions. Actually the convolutions may be and preferably are in direct contact with each other. The wire 20 is coated with enamel or is otherwise treated so that the adjacent convolutions will be insulated from each other. The ends of the wire 20 are connected with suitable terminals 22 and 24 on the blank 12.

The said terminals 22 and 24 are connected with circuit wires 26 and 28, and it will be seen that when the wires 26 and 28 are connected with a source of direct current, there is a continuous drop in voltage in the resistance wire 20 from one terminal to the other, as for instance from the terminal 22 to the terminal 24. A movable electric contact 30 is provided which is adapted to traverse the several convolutions of the wire 20 along a predetermined line of contact therewith. When the blank 12 is flat and when the steps are at one edge thereof, the line of engagement of the contact 30 may conveniently be along the opposite edge of the blank, the wire being abraded along the said line of contact sufficiently to remove the enamel or other coating and to permit direct engagement between the contact 30 and the several convolutions. As shown, the contact 30 is mounted for pivotal movement about a fixed axis at 32 and the blank 12 is correspondingly curved. The contact 30 may continuously engage the convolutions as it is moved, or it may be moved out of engagement therewith and then be brought intermittently into engagement. The contact 30 is connected with a wire 34 and it will be seen that the voltage in the contact 30 and in the wire 34 varies in accordance with the position of the contact with respect to the convolutions of the voltage divider with which it engages.

As will be more clearly apparent from Figs. 4 to 6, the walls of the steps 15 and 17, instead of being perpendicular to the longitudinal lines of the blank, are inclined with respect thereto or are otherwise undercut so that a portion of each narrower section extends longitudinally beyond or underlies the adjacent portion of the next wider section.

In winding the wire 20 on the blank 12, an apparatus such as that shown in Fig. 2 may be used. The apparatus is essentially an engine lathe and may be of any conventional or preferred form. As shown, it comprises a bed 40 carrying a headstock 42 and a tailstock 44. The spindle of the headstock may be driven in any suitable manner, as for instance by a belt engaging a grooved pulley 46. Carried by the headstock 42 and the tailstock 44 are rotatable fixtures 48 and 50 which are adapted to engage and clamp the respective ends of the blank 12. The fixture 48 is rotatable by the spindle of the headstock and the blank serves to rotate the fixture 50 in unison with the fixture 48. Carried by the bed 40 is a carriage 52 which is adapted to be moved longitudinally of the bed by means of a lead screw 54. By means of a suitable gearing, not shown, the lead screw is rotated in timed relationship with the spindle of the headstock so that the carriage is moved along the bed at a rate exactly proportionate to the rate of rotation of the fixtures 48 and 50 and of the blank 12. The carriage 52 is provided with a member 56 having a slot therein through which the wire 20 can pass, the slotted member 56 serving to guide the wire so that it may be automatically wound on the blank in uniformly spaced convolutions when the blank is rotated.

Inasmuch as the blank 12 is noncircular in form, the rate of movement of the wire during winding is not uniform, and in order that the tension in the wire may remain substantially constant notwithstanding variations in the rate of movement, the wire is passed through eyelets 58, 60, 62 and 64 which are positioned at the ends of resilient members carried by the guide mem-

ber 66. The wire passes to the outer eyelet 64 from a suitable spool 68 and during winding the eyelets move laterally in accordance with variations in the rate of winding so as to maintain a substantially uniform tension in the wire.

At the commencement of the winding operation the end of the wire 20 is temporarily secured to the blank at the outer end of one of the end sections thereof, as for instance at the outer end of section 14, the carriage being initially positioned so that the point of attachment of the wire is in alignment with the slot in the guide member 56. Rotation of the blank 12 is then started and the wire is automatically wound on the blank in uniformly spaced convolutions by reason of the movement of the carriage 52 along the bed by means of the lead screw 54. If the automatic winding were to proceed continuously from the smaller section 14 to the larger section 16, the first convolution properly belonging on the larger section 16 might not firmly engage the said section and might slip off from the end thereof and wind on the smaller section 14 on top of the next preceding convolution, thus causing a bunching of convolutions on the said smaller section. Furthermore, a convolution initially formed on the extreme end of the larger section 16 might later slip off during use, thus making a loose convolution which would make the entire divider useless. To avoid this difficulty, each step between two sections, such as the step 15, is inclined or otherwise undercut as already stated. When the automatic winding has proceeded to the position shown in Fig. 3 the speed of rotation is reduced and the operator manually guides the wire 20 so that at least one convolution and preferably two or more convolutions are positioned within the undercut at 15, as shown clearly in Fig. 4. After one or more additional convolutions have been manually guided into position on section 14, as shown and described, the automatic winding of the wire is resumed with the next following convolutions being formed on the next larger section 16, as shown in Fig. 5. It will be seen that the first convolution on the section 16 is substantially spaced from the extreme end of the section so that there is no danger that the convolution may slip off and become loose.

Winding on the section 16 is continued until the position shown in Fig. 5 is reached, whereupon the speed of rotation is again reduced and the operator again manually guides the wire so that at least one convolution and preferably two or more convolutions are positioned within the undercut at 17 as clearly shown in Fig. 6. Thereafter automatic winding is resumed and the next following convolutions are formed on the section 18, as shown in Fig. 6. It will be apparent that the first convolution on the section 18 is substantially spaced from the end of the said section so that there is no danger that the convolution may slip off and become loose. After the winding has been completed, as shown in Fig. 6, the terminals 22 and 24 are attached to the blank 12 and the ends of the wires are connected with the said terminals. If the divider is to be used as shown in Fig. 1, it is bent to the proper curvature after winding has been completed.

It may sometimes be desirable to provide steps at both edges of the blank, as shown in Fig. 8, instead of at one edge only, as shown in Figs. 1 to 7. The blank 68 shown in Fig. 8 has sections 70, 72 and 74 separated by undercut steps 71, 73 and 75. The method of winding for the blank shown in Fig. 8 is substantially the same as that

already described, the wire being guided by hand so that at least one convolution and preferably two or more convolutions are within the respective undercut steps 71, 71 and 73, 73. The ends of the wire are connected with terminals 76 and 78 on the blank. With a voltage divider such as shown in Fig. 8 provision is made for the engagement of a movable contact therewith along a central line such as indicated by the dot-and-dash line A—A. The wires are abraded along this line sufficiently to permit the movable contact to engage therewith.

Fig. 9 shows a voltage divider similar to that shown in Fig. 8 except that the steps at opposite sides are in staggered relation with each other instead of being opposite.

The blank 80 shown in Fig. 9 has sections 82, 84, 86, 88 and 90 separated by undercut steps 83, 85, 87 and 89. The method of winding for the blank shown in Fig. 9 is substantially the same as that already described, the wire being guided by hand so that at least one convolution and preferably two or more convolutions are within the respective undercuts 83, 85, 87 and 89. The ends of the wire are connected with terminals 92 and 94 on the blank. Provision is made for engagement of a movable contact with the voltage divider shown in Fig. 9 along a central line such as indicated by the dot-and-dash line B—B. The voltage divider shown in Fig. 9 has the advantage of providing a larger number of sections of different sizes, thus making it possible for the variation in the voltage to conform more exactly to the theoretically desirable curve. The voltage divider shown in Fig. 9 has the further advantage that it may be more easily wound inasmuch as the manual guiding of the wire into the undercuts can be more conveniently effected.

What I claim is:

1. In a voltage divider, the combination of a flat insulating member having two sections of different widths with an undercut step at the juncture of the sections, and a resistance wire wound on the said two sections to provide a continuous series of uniformly spaced convolutions, the said wire having at least one of the convolutions on the narrower section positioned within the undercut of the said step.

2. In a voltage divider, the combination of a flat insulating member having three sections of different widths with undercut steps at the junctures of the sections, and a resistance wire wound on the said three sections to provide a continuous series of uniformly spaced convolutions, the said wire having at least one of the convolutions on the narrowest section positioned within the undercut of the immediately adjacent step and the said wire having at least one of the convolutions on the intermediate section positioned within the undercut of the other step.

3. In a voltage divider, the combination of a flat insulating member having two sections of different widths with an undercut step at the juncture of the sections, and a resistance wire wound on the said two sections to provide uniformly spaced convolutions, the said wire having one of the convolutions on the narrower section positioned within the undercut of the said step and having the next adjacent convolution extending across the undercut.

4. In a voltage divider, the combination of a flat insulating member having two sections of different widths with an undercut step at the juncture of the sections, and a resistance wire wound on the said member to provide two imme-

diately adjoining groups of uniformly spaced convolutions, one group of convolutions being on the smaller section and the other group of convolutions being on the larger section and the juncture of the two groups being in a transverse plane intersecting the undercut of the said step.

5. In a voltage divider, the combination of a flat insulating member having one continuous edge and having two sections of different widths with an undercut step at the opposite edge joining the sections, and a resistance wire wound on the said two sections to provide a continuous series of convolutions, the said wire having at least one of the convolutions on the narrower section positioned within the undercut of the said step.

6. In a voltage divider, the combination of a flat insulating member having a plurality of sections of different widths with undercut steps at the opposite edges joining adjacent sections, and a resistance wire wound on the sections to provide a continuous series of convolutions, the said wire having at least one convolution positioned within the undercut of each of the said steps.

7. In a voltage divider, the combination of a flat insulating member having two sections of different width with oppositely disposed undercut steps at the opposite edges of the member joining the said sections, and a resistance wire wound on the said two sections to provide a continuous series of convolutions, the said wire having at least one of the convolutions on the narrower section positioned within the undercuts of both of the said steps.

8. In a voltage divider, the combination of a flat insulating member having three sections of different widths with undercut steps at the opposite edges of the member joining each two adjacent sections, and a resistance wire wound on the three sections to provide a continuous series of convolutions, the said wire having at least one convolution positioned in the undercut of each of the said steps.

9. In a voltage divider, the combination of a flat insulating member having a plurality of sections of different widths with undercut staggered steps at the opposite sides of the member joining each two adjacent sections, and a resistance wire wound on all of the sections to provide a continuous series of convolutions, the said wire having at least one convolution positioned in the undercut of each of the said steps.

10. The method of making a voltage divider which comprises in combination, forming a flat insulating member having two sections of different widths and provided with an undercut step at the juncture of the sections, rotating the member about a longitudinal axis, attaching one end of a long wire to the member near one end thereof, moving a guiding means for the wire longitudinally at a speed proportionate to the speed of rotation so as to be adapted to cause the wire to wind on both sections of the member in uniformly spaced convolutions, and separately guiding the wire manually at the juncture between the two sections of the member to cause at least one convolution on the narrower section to be positioned within the undercut of the said step.

11. The method of making a voltage divider which comprises in combination, forming a flat insulating member having a plurality of sections of different widths and provided with undercut steps at the junctures of adjacent sections, rotating the member about a longitudinal axis, attaching one end of a long wire to the member near one end thereof, moving a guiding means for the

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wire longitudinally at a speed proportionate to the speed of rotation so as to be adapted to cause the wire to wind on all of the sections of the member in uniformly spaced convolutions, and separately guiding the wire manually at the juncture between each two sections of the member to cause at least one convolution thereof to be positioned within the undercut of each step.

12. The method of making a voltage divider which comprises in combination, forming a flat insulating member having two sections of different widths and provided with undercut steps at opposite sides joining the two sections, rotating

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the member about a longitudinal axis, attaching one end of a long wire to the member near one end thereof, moving a guiding means for the wire longitudinally at a speed proportionate to the speed of rotation so as to be adapted to cause the wire to wind on both sections of the member in uniformly spaced convolutions, and separately guiding the wire manually at the juncture between the two sections of the member to cause at least one convolution on the narrower section to be positioned within the undercuts of the two steps.

HORACE H. RAYMOND.