Sept. 11, 1951 R. D. HELLER 2,567,770

WIRE STRAIGHTENER

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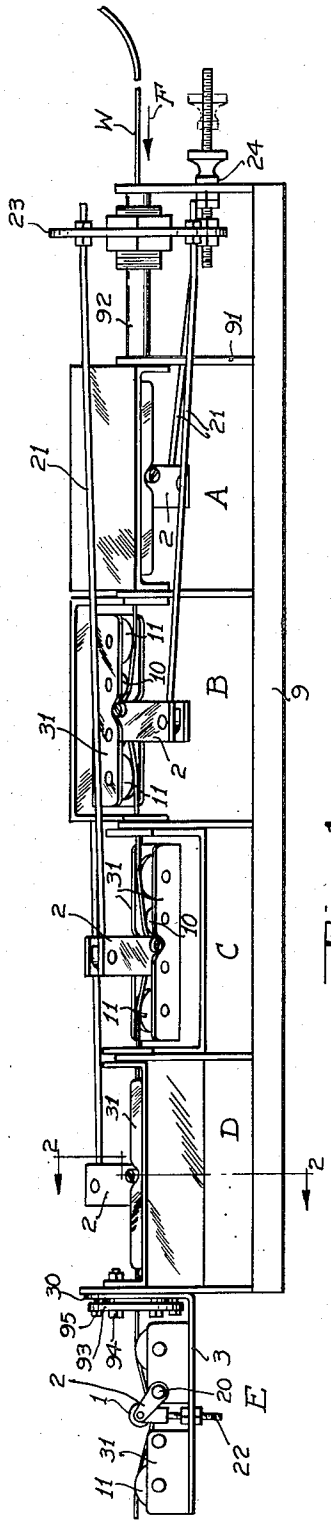


Fig. 1

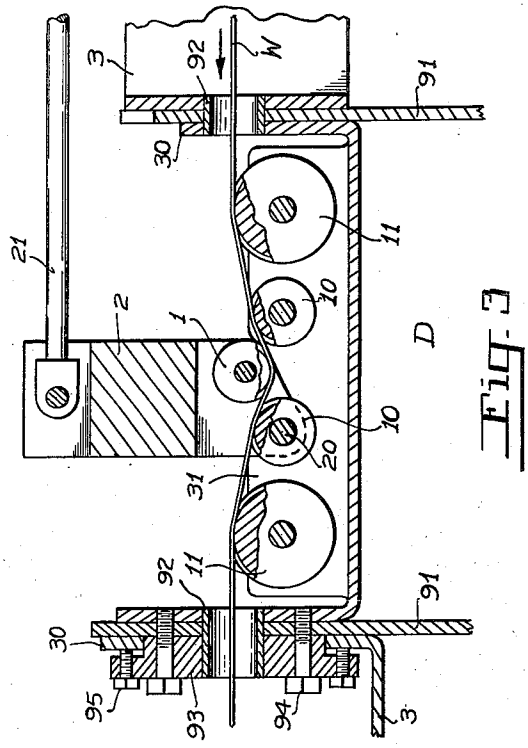


Fig. 3

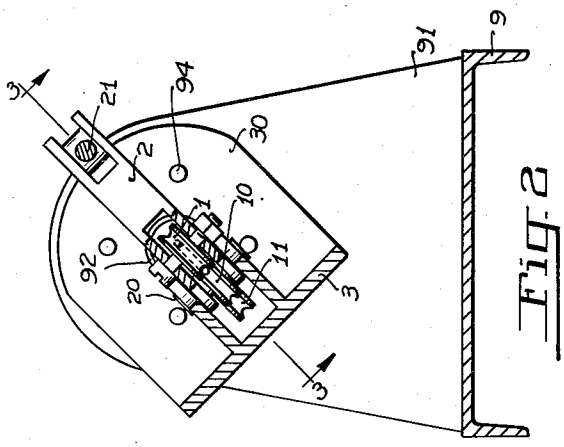


Fig. 2

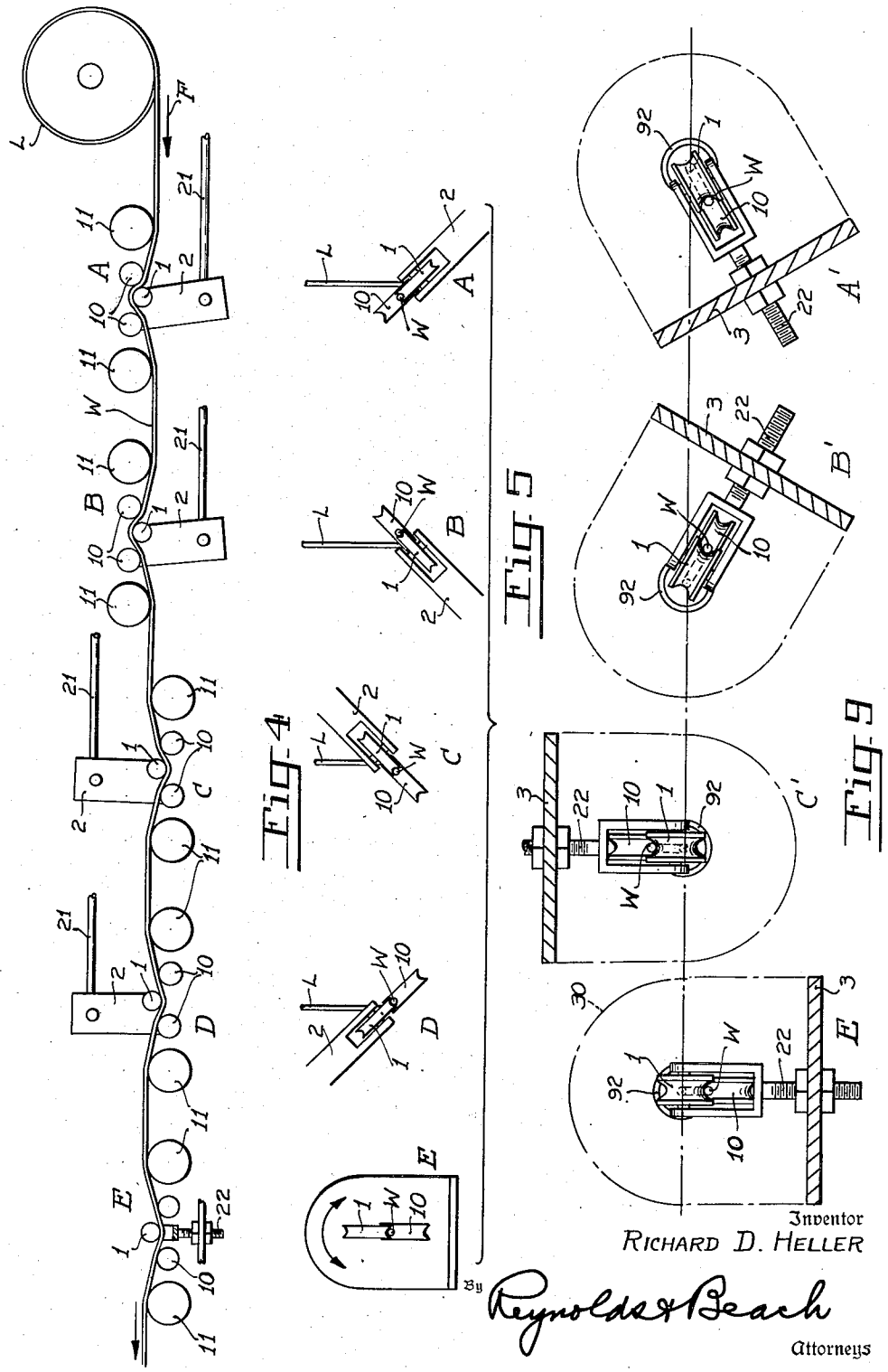
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WIRE STRAIGHTENER

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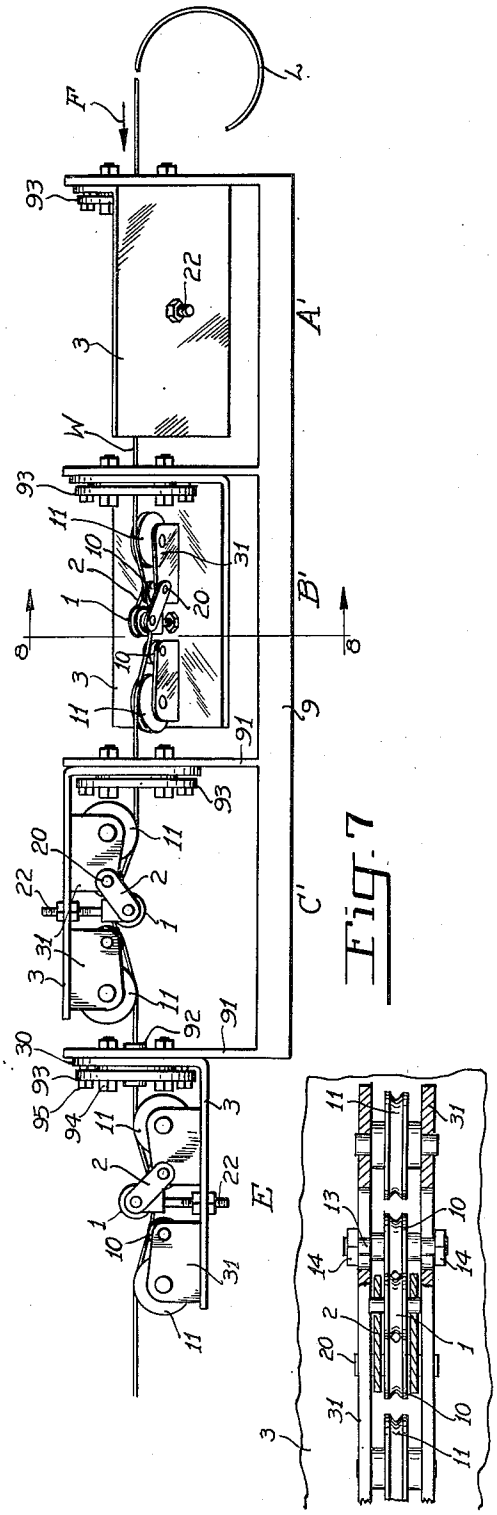


Fig. 7

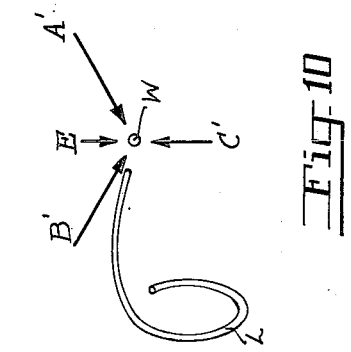


Fig. 10

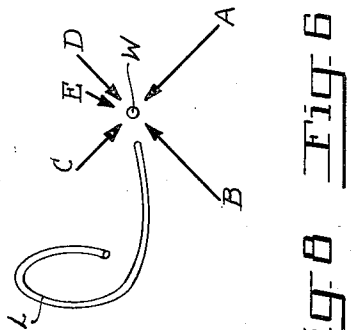


Fig. 6

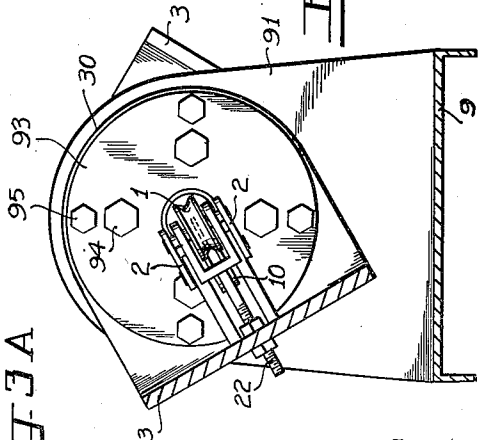


Fig. 8

Fig. 3A

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WIRE STRAIGHTENER

Richard D. Heller, Tujunga, Calif.

Application September 7, 1946, Serial No. 695,497

30 Claims. (Cl. 140—148)

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The present invention concerns a wire straightener, and is primarily designed for straightening wires or rods of larger diameter or gauge, and consequent inherent stiffness, as distinguished from the wire straightener of the type disclosed in my copending application Serial No. 668,789, filed May 10, 1946, now Patent No. 2,462,396, issued February 22, 1949, which is primarily designed for smaller wires.

All wire, as it is manufactured, is wound in coils about a reel, swift, or the like. Thereby it acquires a permanent set, and tends to remain in coiled form when removed or unwound from the reel. The molecules of the metal within the wire tend to retain their disposition relative to all other molecules therein. Since it is undesirable in most manufacturing processes or products using such wires to permit this set to remain in the wire, it is customary to employ wire straighteners, acting upon the wire as it is unreeled, to remove this set preliminarily to incorporating the wire in manufactured products. However, unless the wire is correctly and perfectly straightened, the random irregularities of the imperfectly straightened wire may often cause more difficulties in its subsequent handling than if it were left with its nearly uniform initial set. Most wire straighteners heretofore available, with the exception of that of my companion application, have required tedious, careful, and multiple individual and relative adjustments of a large number of bending elements, which could be done properly only by workmen of considerable skill and experience. One of the objects of the present invention is to simplify the straightening operation, and to enable its accomplishment quickly, easily, and with a minimum of skill and experience.

One reason for distinguishing between wires on the basis of their size, and for employing for larger wires a straightener different from the one of my companion application, which is designed for straightening primarily smaller wires, lies in the tendency of a stiff wire to resist straightening to such an extent that it tends to rotate on its own axis, if any counterbending force is applied to it directed—or intended to be directed—precisely oppositely to its coil set. It is virtually impossible to guide a stiff, uncoiling strand, as it runs rapidly over rolls or the like, so accurately

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that the plane of its coil will not tend to tilt under the influence of such a counterbending force to one side or the other of the plane defined by the strand's path and the direction of the counterbending force; generally the stiff strand will tilt now to one side, now to the opposite side of such plane, if the counterbending force be applied directly oppositely to the coil plane. If a reliable way of securing the strand against torsional rotation under such conditions could be found, there would be less need of avoiding direct counterbending, but in the absence of such torsion-resisting means it seems necessary to apply counterbending forces first from one side of the coil plane, thus assuring that all tilting tendency is uniform and to a common side of the initial coil plane, and immediately thereafter to apply another counterbending force from the opposite side of the initial coil plane, thus assuring that its tilting tendency is uniform and all to the opposite side of the initial coil plane, thus neutralizing the torsional rotational tendency of the first counterbend. The value of each counterbending force complements that of the other, and the sum of their effects—both being generally oppposite to the initial coil set, though directed from opposite sides of the coil plane—is substantial neutralization of the coil set. Another cooperative effect is their tendency to cradle the strand, each resisting or neutralizing any tendency of the other to tilt or to rotate the strand about its own axis, and thus combining to hold it effectively against rotation when, in a subsequent counterbending operation, any residual set is removed.

It is an object, therefore, to effect counterbending by a method and means wherein, by relating the direction of counterbending forces to the plane of the initial coil set, torsional rotation of the strand is minimized, and uniformity of results are assured, particularly when dealing with large or stiff wire.

A further reason why the size and stiffness of the wire introduces problems not involved in the machine and operations of my patent referred to above, lies in the nature of the straightening operation. Straightening is a rearrangement of the internal molecular relationships. If the wire is small and thin it bends easily, and even when the bend for straightening is directly opposite

the initial set the internal stresses are small; moreover, if the wire is weakened somewhat thereby, being small it was not initially strong, and the weakening is inconsequential. With a larger wire the internal stresses caused by direct counterbending are quite appreciable; the more nearly directly opposite are such counterbends to the initial set the more violent and weakening is the rearrangement of the molecules caused thereby. Direct counterbending tends, as it were, to "break the back" of the wire. Since larger wires are employed, usually, because strength is required, any such weakening becomes much more serious than in smaller wires.

Accordingly, it is another object of this invention to effect the straightening of wires, particularly larger wires, which while effective will not to any serious degree lessen the strength of the wire, in that the counterbending is directed obliquely, not directly oppositely, with relation to the initial set.

A still further reason for distinguishing between wires on the basis of their size, in straightening operations, concerns the ability to thread them through the straightener. Small, flexible wires can be threaded through small passages and an intricate or sinuous pathway, but larger wires, being less flexible and manageable, can not be, at least without great difficulty and at considerable expense in time. A further object of the present invention, adapting it for use with larger wires, is to provide a wire path which is open and accessible to the maximum degree, and also, one which can readily be opened widely, to facilitate threading through or similar engagement therewith of larger wires.

The counterbending forces applied to smaller and more flexible wires need not be individually large, and particularly so if they are aggregated with other such forces by repeated bends back and forth. Larger wires can not be bent thus repeatedly, for this has a tendency to anneal them, and thus would seriously weaken them, hence a still further object of this invention is to effect the straightening by employing a minimum number of bends, each gradual, and without repeated reversals of the bend in the wire, but to do this by devices capable of applying a sufficient force, and adjustable readily to apply just the correct amount of force, and in just the correct directions, to the wire as it is pulled through the straightener.

More specifically, and in association with a previously expressed object, it is a further object of the present invention to effect the bending by at least two relatively angularly disposed primary bending devices, disposed at opposite acute angles to the plane of the initial coil set, and, to the degree that rotation is not otherwise preventable, disposed also substantially equiangularly at opposite sides of the coil's plane, and, as one way to minimize the tendency of the wire to rotate one way or another about its own axis by forces generated by such primary bending devices, it is a further object to provide devices, preferably in the same form and similarly directed as the primary bending devices, but less forcefully applied, which will resist such torsional rotation of the strand, so that it may be delivered, after its passage through the bending device, substantially straight and free from set or bend.

However, since it will often prove difficult to accomplish this latter end without extremely careful individual adjustments, which it is desirable to avoid, it is a further object to provide, in conjunction with the wire straightener, a final bank which is (or in some cases separate bending and torsion-resisting banks which are) rotatably adjustable about the axis of the strand to any desired angular position, and so arranged or individually adjustable as to apply just the amount of force, and in just the proper direction or plane, to effect the final corrective straightening to overcome any residual set after the wire has passed through the main straightener, or to effect the bending most advantageously, with minimum need for a corrective straightener.

It is also an object to provide in such a straightener a number of banks of wire guiding and bending devices, angularly disposed about the central strand path, and to provide in such banks adjusting means, both such as are individual to the several banks, and also which are common to all banks, excepting, possibly, the final corrective bank.

It is an object in each bank to employ a simple arrangement, preferably of rolls, through which the wire can be very readily threaded, since most of them lie at one side of the strand, and further in connection with such a set of rolls it is an object to arrange them in such a way, and of such sizes, as will accomplish the desired bending by a series of gradual bends, all in one direction, with only a single abrupt or semiabrupt reversal of the strand, rather than a plurality of reversals or repeated counterbends.

It is also an object in such a wire bending bank to provide means readily adjustable to vary the degree or abruptness of the bends in the strand.

Finally, it is an object in general to provide a wire straightener of simple construction, rugged, and thoroughly reliable, the principles whereof are adapted not only to use with wires of large gauge, but which can be used with wires of any gauge.

Various other objects, more particularly such as relate to the mechanical structure of the device and of its various parts, and their combination and arrangement relative to one another, and such as relate to the method phases of the present invention, will be better ascertained as this specification progresses.

In the accompanying drawings the invention is shown embodied in a form such as is presently preferred by me, although it will be understood that various changes may be made in the form, character, and relative arrangement of the parts within the scope of the claims as hereinafter set forth, and indeed that the method may be practiced by mechanism altogether different from that herein illustrated.

Figure 1 is a general elevational view of one form of the machine, such as includes four banks arranged at 90° to one another, and adjustable in common as well as individually, together with a fifth corrective bank independently adjustable.

Figure 2 is a transverse section substantially along the line **2—2** of Figure 1, and Figure 3 is a longitudinal section substantially along the line **3—3** of Figure 2.

Figure 3A is a sectional view illustrating a detail of an adjustably mounted element, which is the subject of an optional modification of the machine of the preceding and subsequent figures.

Figure 4 is a diagrammatic showing of the relationship of the rolls in the several banks in the

machine of the type illustrated in Figure 1, and Figure 5 is a companion diagrammatic showing, illustrating the actual relative angular relationship of the banks illustrated in Figure 4.

Figure 6 is a force diagram, looking generally along the central wire path, illustrating the force relationships of the several banks in the form of the machine shown in Figures 1, 2 and 3.

Figure 7 is a general elevational view, similar to Figure 1, of a different form of the machine, and Figure 8 is a view corresponding to Figure 2, and taken on the line 8—8 of Figure 7.

Figure 9 is a diagrammatic view somewhat similar to Figure 5, illustrating the angular relationship of the banks in the form of machine shown in Figures 7 and 8.

Figure 10 is a force diagram similar to Figure 6, but illustrating the relationship of the banks to each other and to the wire with a machine such as is illustrated in Figures 7 and 8.

The form of the machine which is illustrated in Figures 1 to 6, inclusive, is composed of four banks of wire guides designated, in succession as they are reached by the wire strand W being pulled through, by the letters A, B, C and D. A fifth bank E is the corrective bank optionally used for correction of any residual set after the strand has passed through the first four banks. In this form of the machine, the banks A and B may be considered as the primary bending banks, and the banks C and D as torsion-resisting banks, the principal purpose of which is to prevent the strand W from rotating about its own axis, and by so doing avoiding proper engagement by the bending rolls of the banks A and B.

All such banks are preferably constructed substantially alike, although the adjustment of the bending roll with respect to adjacent rolls may be different in the primary bending banks and in the torsion-resisting banks. However, a description of the structural features of one will suffice for the others, and such a bank is shown in detail in Figure 3, and to a certain extent in Figure 2. Thus a frame 3, with flanged ends 30 adapted for supporting engagement from brackets 91 upstanding from the machine base 9, is arranged for the support of at least three, and preferably five, grooved rolls. The rolls' immediate support may consist of longitudinal flanges 31, forming in effect a channel. The rolls referred to, which typify any convenient strand guides, comprise terminal rolls 11 for leading the strand into and from each bank, paired inner rolls 10, and the active bending roll 1 interposed between the spaced-apart rolls 10.

The arrangement of these rolls relative to one another and to the central axis of the machine is of importance. The strand's axis is defined by the terminal rolls 11, or more exactly speaking, by the bottom of the grooves of all the terminal rolls 11, which are set in alignment throughout the machine. These terminal rolls 11 are preferably of larger radius than the other rolls, in order that the strand will not be abruptly bent and its internal molecular relationship materially altered in passing over them. In any given bank both such terminal rolls are at one side of the strand. The inner rolls 10 are likewise both at the same side of the strand as the terminal rolls 11, but preferably are of somewhat smaller radius in order to cooperate better with the bending roll 1 interposed between them. The middle roll 1 is mounted at the opposite side of the strand from the other rolls of its bank, and is so mounted that it may be moved inwardly

and outwardly between the inner rolls 10 to effect greater or lesser deflection of the strand in its passage between the two rolls 10. Also, such adjustment permits opening wide the space between the rolls 1 and 10, to facilitate insertion of the strand into the straightener. For the purpose of so adjusting the middle roll 1, it may be journaled upon a lever 2 fulcrumed, for example, at 20 at the axis of one of the rolls other than the middle one, and capable of rocking on this axis by control means, such, for example, as the rod 21 or the screw and lock nut 22. Such adjustment may be affected within each individual bank, as in the form of the machine shown in Figures 7, 8, and 9, or each rod 21 may be individually adjustable with respect to a common disc 23, which latter is adjustable for adjustment of all the banks in common, by the adjusting means indicated at 24 in Figure 1. No springs are employed to apply a bending force to the strand, but instead, all forces are positive and fixed, once adjusted, hence must be accurate.

The middle roll 1 is adjustable by rocking of the lever 2 about the axis of an inner roll 10, in the machine shown, and this affords the most favorable leverage. The spacing between the rolls 10 is necessarily slight, so that for some operative positions of adjustment the roll 1 may approach too close to or be spaced too far from the other roll 10. Desirably, the distance from the roll 1 to each of the rolls 10 should be the same, but if both rolls 10 are fixedly journaled in the flanges 31, necessarily such distances will not be the same for all adjusted—in and out—positions of the roller 1 and its lever 2, but will vary for each such adjusted position. In some instances the difference may be immaterial, but in order to equalize these distances in such cases as make equality desirable, the one roller 10 may have its pintle 13 project at each end through longitudinal slots in the channels 31 (see Figure 3A), and adjusting or holding means, typified by the set nuts 14, may pinch and engage such projections to retain them in position lengthwise of their slot. By some such means both rollers 10 may be kept equidistant from the roller 1, whatever the adjusted operative position of the latter.

It will be clear that the individual banks are arranged in alignment, with bushings 92 defining apertures through the brackets 91 and flanges 30 through which the strand W may pass. Considering, in the companion Figures 4 and 5, that the wire strand is to be unreeled from a reel, the plane of which is represented by the loop or coil L, and is to be drawn in the direction of the arrow F, the first bank is arranged, as Figures 5 and 6 show, in such fashion that the middle roll 1 deflects the strand materially and in part reversely to the set which the strand has acquired within the loop L, but this deflection in the primary bending banks is not in the same plane as the plane of the loop or coil L. Indeed, with stiff wire such as this machine is intended to straighten, and in the absence of any provision immediately in advance of the first bank A for preventing rotation of the strand about its own axis, it would in practice be impossible to apply or to maintain a counterbending force at this point always directly oppositely to the coil set in the strand, and always precisely in the coil plane thereof. The stiff, bent strand would inevitably rotate between successive rolls, to one side or to the other of the direction of the counterbending force, or perhaps would rotate now to one side and then to the other side, uncon-

trollably. Under such conditions, regardless of any desire or attempt to maintain coincidence between the direction of the counterbending force and the coil plane, the force would inevitably be in a direction having a component laterally of the coil plane.

It is considered preferable, therefore, to displace the coil plane angularly relative to the direction of the counterbending force—or vice versa—at least sufficiently that the coil will not be able to tilt its plane to the opposite side of the direction of the force, and thereby to achieve, among other advantages, uniformity of counterbending. Accordingly, the strand guides and the deflecting roll 1 are so arranged that the deflection has a component laterally of the plane of the coil, so that the strand is bent somewhat sidewise, and not directly back upon itself; see Figure 5. The extent of the lateral component, as related to the coplanar component, depends upon the angular position of the bank relative to the coil's plane, and in the machine shown in Figures 1 to 6 the first bank A is arranged at 45° to the plane of the coil L. It is preferred that the angle between the direction of the counterbending force and the coil plane be never as great as 90°, for an angle of 90° in bank A coupled with an angle of 90° in bank B—as will shortly appear more fully—would eliminate any cradling effect, later referred to. In practice it has been found preferable that an angle of 60° be not exceeded in any bank. As to the minimum angle, that depends upon the certainty or lack of certainty with which the strand can be kept from rotating or tilting about its own axis during counterbending. If it could be assured that the strand could be held absolutely against rotation, theoretically the counterbend, if gradual enough, could be directly in the coil plane, and could be accomplished in one single bank. Since in practice that is impossible, the counterbending force is directed at such angle to the coil plane as will assure that the strand will not rotate, nor its coil plane tilt oppositely, and this angle can be the smaller as provision is made the more certainly to prevent the strand's rotation, or conversely, must be made the larger—within the maximum limits discussed above—as such assurance against rotation is lacking.

It will already be apparent that the next bank B, which is also arranged as a primary bending bank, should operate upon the strand to bend it somewhat oppositely to the initial set of the strand, and yet also somewhat oppositely to the counterbend produced in the bank A. If the bank A is set at 45°, the bank B would be set approximately at 45° to the plane of the loop L, but at the opposite side of the coil's plane from the bank A. The bends in banks A and B are generally equiangularly disposed at opposite sides of the initial coil plane, or, in the example given, at 90° one to the other. In the bank B, as in the bank A, the strand is given a deflection which includes a lateral as well as a directly opposed component, and thus the wire is bent first to one side and then to the other of the plane of its coil, and in both instances somewhat oppositely to its initial set, and yet never is the initial set directly opposed nor counterbent. By proper adjustment of these two primary bending banks the entire initial set of the strand can be overcome. Moreover, each tends to counteract the strand-rotative tendency of the other, by cradling the strand in the valley they cooperate to form, and hence the net result is to minimize, if not to prevent absolutely, the torsional rotation of the strand about its own axis, during counterbending.

The banks C and D, however, serve a very necessary function, namely, to prevent torsional rotation of the strand beyond and hence within the bank B, and hence to minimize its rotation by the deflection applied to it in each of the primary bending banks A and B. The banks C and D cooperatively oppose the bends in the banks A and B, and more especially the rotative effect of bending in the bank B. It is not strictly necessary that each be diametrically opposite one of the primary bending banks; they are so shown, however, for convenience, and because this has been found a satisfactory way of resisting torsional rotation of the strand. However, differently from the rather marked and abrupt deflection caused in the banks A and B, the deflection caused in the banks C and D is quite mild, just sufficient that these two banks in conjunction one with another will cradle the strand, as it were, and prevent its torsional rotation about its own axis. They effect no extensive rearrangement of the molecular structure of the strand, whereas there is an appreciable molecular rearrangement as the wire passes through the banks A and B.

Since it is undesirable to require extremely accurate adjustment of the rolls in the banks A and B, nor for that matter in the banks C and D, indeed, pointless, because the strand's set varies according to whether its individual coils come from near the axis or from near the periphery of the reel whence it is unwound, and an adjustment suited to correct one will under- or over-correct for the other, it is considered preferable to adjust them approximately to the correct degree to straighten the wire, having regard, of course, for its gauge or thickness, and then to remove any residual set by passing the strand through a final corrective bank E. In this corrective bank the flange **30** of the individual bank is apertured for rotation, as by mounting it upon a shouldered collar **93** held to the brackets **91** by the bolts **94**. By tightening down the set screws **95**, the frame **3** of the corrective bank E may be fixed or set, in any rotated position through 360° about the axis of the strand. This bank of rolls is the same in construction and arrangement as the banks already described, save that its middle roll **1** is not adjustable in common with the middle rolls of any other bank, but rather is individually adjustable by the adjusting screw **22**.

After the strand has passed through the banks A, B, C and D, any residual set is noted, the bank E is rotated so that its middle roll **1** is directly opposite the slight residual set, and the transverse position of the roll **1** is adjusted so that it just removes this residual set. This will never require any extensive counterbending, for otherwise more exact adjustment of the preceding banks is required, and so the strand may be counterbent directly oppositely to this residual set without danger of weakening it.

It will be clear from the drawings that the threading of the wire through the machine is a comparatively simple job. It is only necessary to move the adjusting collar **23** to the left, as viewed in Figure 1, and this moves all the bending or middle rolls **1** outwardly into inoperative position spaced to the maximum from the rolls **10**. The wire is now threaded through the bushings **92** and is merely laid in the grooves of the rolls **10** and **11** and under each roll **1** until it

finally, after the passage through the successive banks in this fashion, is drawn through at the delivery end of the straightener. At first the corrective bank E is not brought into operation. The collar 23 is then moved to the right, orienting the rolls correctly with regard to the plane of the coil L, until a sufficient counterbend is accomplished to deliver the wire approximately straight. The corrective bank is then brought into operation, if necessary, and the bending proceeds by pulling or pushing the wire through by means not shown, until all the wire has been relieved of its initial set, and issues substantially straight.

It is to be noted here that with the coil plane as shown at L in Figure 6, the force applied by the banks A and B is in general opposite to this initial set, and the force applied in the banks C and D, which is in the same general direction as this set, is much less, as represented by the difference in length of the arrows. The force applied at the corrective bank E may be appreciably less than in any of the preceding banks, and may be at any point 360° about the strand's axis, as indicated by the arrow E. However, should the plane of the coil be not upright, as viewed in Figure 6, but horizontal, it would be incorrect to attempt to effect the primary bending by the banks A and B, for then one of these banks would only tend to bend the strand in the sense it is already bent. Instead, the primary bending would be accomplished in such a case by the cooperative action of the banks A and D, or B and C, depending upon whether the coil lies to the left or to the right as viewed in Figure 6 from the delivery end. It is for the purpose of enabling adjustment of the extent of deflection accomplished in the individual banks, so that two primary bending banks cooperate to cradle the strand, and two torsion-resisting banks (when two are used) similarly cooperate to cradle the strand, that each lever 2 is individually adjustable by reason of the connection between its rod 21 and the common disc 23. The device will operate equally well whether the primary bending be accomplished in two immediately succeeding banks, or in banks which are spaced apart by an intervening torsion-resisting bank.

As will now be apparent, the 90° spacing of the banks A, B, C, and D, which is illustrated in the figures so far discussed, is not essential. It is desirable that the two primary bending banks be substantially equiangularly disposed at opposed sides of the coil plane, and that they operate upon the strand through some angle less than 180°, in order that there may be a component which is opposed to the initial set, as well as a lateral component. Likewise, while in some instances it may be desirable that the resistance to torsion be accomplished by passage through two partially opposed banks, such is not necessarily the case in all instances, as has already been pointed out.

In Figures 7 and 8 an arrangement has been shown in which there are but three banks A', B' and C' in the principal part of the machine, supplemented by one additional corrective bank E, which latter may be the same as previously described. The banks A', B' and C' are substantially the same as the banks previously described, except in two particulars—the adjustment of the middle roll in each such bank is independent of the adjustment of the corresponding roll in the other banks, and each such bank is mounted for rotation about the axis of the wire path independently of such adjustment of the other banks. Somewhat differently expressed, the machine of Figure 7 is composed of four banks all similar to the corrective bank E, but in which the first three banks A', B' and C' are normally disposed, in the illustrative form herein, at about 120° to one another, though independently rotationally adjustable, and only the bank E, when used, is intended normally to be rotated to any point at 360° about the axis of the wire path.

Referring to Figures 9 and 10, it will be seen that the banks A' and B' are arranged with respect to the plane of the coil, indicated at L in Figure 10, so that there is an opposed or counterbending component, but also a very considerable lateral component, impressed upon the strand as it is pulled through these banks A' and B', and it will be noted also that they are so arranged as to lie equiangularly at opposite sides of the plane of the loop L. However, instead of two torsion-resisting banks there is but a single bank C', the force of which (see Figure 10) is lesser than the substantially equal forces applied by the respective banks A' and B', and this has been found adequate to resist the torsion in such a machine. The corrective bank E, rotatable about the axis of the strand, removes any residual set, and, of course, any of the banks A', B' and C' can be, if desired, rotated about the axis of the strand to alter the direction of application of the counterbending forces.

The flexure of the strand is first, even though slightly, in the direction tending to increase its initial set, as it passes over the large entrance roll 11 of each primary bending bank. This effect is increased as the strand passes next over the smaller roll 10, but immediately it is reversely bent, and rather abruptly, in passing beneath the small roll 1, and thence up and over the roll 10. Again its direction of bend is gently reversed as it passes out over the latter and the larger final roll 11. Such effect as may be produced by the initial flexure in the general direction of its initial set, if there is any such effect, is a loosening of the internal molecular arrangement, and consequent preparation thereof for the more abrupt reversal which follows. Yet, because the reversal is in part lateral, it rearranges the internal molecular relationships without such violent crowding of them together, at the compression side of such reverse bend, and without such forcible rending of them apart at the tension side thereof, as would occur were the reverse bend directly opposite to the initial set. The greatest stresses are applied to previously unstressed or but lightly stressed zones of the strand's cross-section, and its previously stressed zones lie to a considerable degree in the neutral zone of the reverse bend. In consequence, the flexures, combined, effect adequate molecular rearrangement, without minute multiple ruptures to weaken the strand.

The two cooperative primary bending rolls may be thought of as cradling the unreeling coil from opposite sides, and if one such roll tends to rotate the plane of the coil about the strand's axis in one direction, the companion roll tends equally to rotate the coil's plane in the opposite direction, hence each roll tends to counteract the other. Actually, and because they operate successively and not simultaneously upon any given portion of the strand, this counteraction of the two primary bending rolls is not alone sufficient, in most cases, to prevent rotation of the strand about its own axis, and that is why the torsion-resisting rolls are employed. The coil-rotating

tendency of each such torsion-resisting roll is slight, and is resisted by the opposite tendency of the other such roll, when two are used, and by the opposite tendency of one of the primary bending rolls. The coil, then, is cradled from opposite sides by the two primary bending rolls, which by their cooperation tend to prevent rotation of the coil's plane in either direction, and the coil may be further cradled in the same fashion by two opposed torsion-resisting rolls. In similar fashion the coil may be thought of as cradled between each primary bending roll and the oppositely (or an angular) directed torsion-resisting roll.

The primary consideration in this invention lies in the orientation of the bending forces relative to—at opposite sides of—the plane of the strand's coil. This assures that each will counteract the tendency of the other to rotate the strand, and assures uniformity of counterbending. It is not sufficient merely to bend the strand in any two different planes chosen at random; each of those planes must be oriented correctly with relation to, and in general equiangularly at opposite sides of, the initial coil plane. Since the latter result can only be obtained dependably when the strand is prevented from rotating, a secondary consideration herein lies in so preventing rotation by suitable means, as by the expedient of cradling the strand between the cooperative bending banks, and between the torsion-resisting banks cooperative with one another or with a bending bank. A third consideration herein lies in the avoidance of unduly abrupt bends in the large, stiff strand, with consequent weakening thereof.

I claim as my invention:

1. The method of straightening coiled wire which comprises advancing the wire strand through a path which is centered upon the strand's axis, guiding the strand at spaced points along its path and in its axis, deflecting the strand, intermediate adjacent guide points, from such axis and back to the same, two of such deflections being opposite to the strand's initial set but in planes generally equiangularly disposed at opposite sides of the coil plane, meanwhile restraining the wire strand against rotation about its axis.

2. The method of straightening coiled wire which comprises pulling the wire strand through a path which is centered upon the strand's axis, guiding the strand, at points spaced along such path and lying in such axis, deflecting the strand, intermediate adjacent guide points, from such axis and back to the same, two of such deflections being opposite to the strand's initial set but in planes generally equiangularly disposed at opposite sides of the coil plane, at least one further deflection being lesser in amount than and generally opposite to the offset of the aforesaid deflections, to resist rotation of the strand about its axis.

3. The method of straightening coiled wire which comprises pulling the wire strand through a path which is centered upon the strand's axis, guiding the strand, at points spaced along such path and lying in such axis, deflecting the strand, intermediate adjacent guide points, from such axis and back to the same, two of such deflections being opposite to the strand's initial set but in planes generally equiangularly disposed at opposite sides of the coil plane, two further deflections being lesser in amount than and directed in planes generally coincident with but in directions opposite to the respective aforesaid deflections, to resist the tendency of the strand to rotate about its axis under the influence of the aforesaid deflections.

4. The method of straightening coiled wire which comprises pulling the wire strand through a path which is centered upon the strand's axis, guiding the strand, at points spaced along such path and lying in such axis, deflecting the strand, intermediate adjacent guide points, from such axis and back to the same, two of such deflections being opposite to the strand's initial set but in planes generally equiangularly disposed at opposite sides of the coil plane, meanwhile restraining the wire strand, by deflection intermediate certain other of said guide points, against rotation about its axis, and in immediate succession similarly offsetting the strand in such selected plane about its axis and to such selected degree as is required to remove any residual set.

5. The method of claim 3, characterized in the disposition of the planes of the two deflections therein specified at approximately 90° to one another.

6. The method of claim 3, characterized in the disposition of the planes of the two deflections therein specified at approximately 90° to one another, and further characterized in that the strand in its passage is further deflected, by lesser amounts, in planes generally coincident with but in directions opposite to the respective first-mentioned offsets.

7. The method of claim 3, characterized in the disposition of the planes of the two deflections therein specified at approximately 120° to one another, and further characterized in that the strand in its passage is further deflected, by a lesser amount, in the plane of the coil and in the direction of its initial set.

8. The method of straightening coiled wire which comprises unreeling the wire strand by pulling upon it, and as it unreels bending it oppositely to its initial set but in a plane at an angle to the plane of its coil, and then bending it again, oppositely to its initial set but in a plane at the opposite side, from the first bending, of the plane of its coil.

9. The method of straightening coiled wire which comprises unreeling the wire strand by pulling upon it, and as it unreels bending it oppositely to its initial set but in a plane at an angle to the plane of its coil, and then bending it again, oppositely to its initial set but in a plane at the opposite side, from the first bending, of the plane of its coil, meanwhile applying a force to the unreeling strand generally opposing the forces accomplishing the aforesaid bending, to restrain the strand's bend-induced tendency to rotate about its axis.

10. The method of straightening coiled wire which comprises unreeling the wire strand by pulling upon it, and as it unreels bending it oppositely to its initial set but in a plane at an angle to the plane of its coil, and then bending it again, oppositely to its initial set but in a plane at the opposite side, from the first bending, of the plane of its coil, meanwhile applying a force to the unreeling strand generally opposing the forces accomplishing the aforesaid bending, to restrain the strand's bend-induced tendency to rotate about its axis, and thereafter bending the unreeling strand in such plane about its axis, and to such degree, as may be required to counteract any residual set.

11. A wire straightener comprising the plu-

rality of banks of wire guides, each bank including at least three guides all in a common plane, the first and last guides in each bank constituting terminal guides, and being disposed along a central path common to all banks, the middle guide in each bank being arranged to deflect the wire strand, as it passes, from the central path defined by the several terminal guides, and the several banks being arranged along such path and in different planes radially about that path, two of such banks, constituting the primary bending banks, being arranged angularly less than 180° relative one to the other, and to lie approximately equiangularly at opposite sides of the plane of the strand's coil, and each for deflection of the strand generally but not directly oppositely to its initial set.

12. A wire straightener comprising a plurality of aligned banks of grooved wire-guiding rolls, each bank including at least three rolls all in a common plane, the first and last rolls in each bank constituting terminal guides, and being disposed along a central path common to all banks, the middle roll in each bank being arranged to deflect the wire strand, as it passes, from such central path defined by the several terminal rolls, and the several banks being arranged along such path and in different planes radially about that path, two of said banks, constituting the primary bending banks, being arranged angularly less than 180° one relative to the other, and to lie approximately equiangularly at opposite sides of the plane of the strand's coil, and each for deflection of the strand generally but not directly oppositely to its initial set.

13. A wire straightener comprising a plurality of aligned banks of grooved wire-guiding rolls, each bank including at least three rolls all in a common plane, the first and last guides in each bank constituting terminal guides, and being disposed along a central path common to all banks, the middle roll in each bank being arranged to deflect the wire strand, as it passes, from the central path defined by the several terminal rolls, the several banks being arranged along such path and in different planes radially about that path, two of said banks, constituting the primary bending banks, being arranged angularly less than 180° one relative to the other, and to lie approximately equiangularly at opposite sides of the plane of the strand's coil, and each for deflection of the strand generally but not directly oppositely to its initial set, and means to adjust the position of each deflecting roll transversely of the central strand path.

14. A wire straightener comprising a plurality of aligned banks of grooved wire-guiding rolls, each bank including at least three rolls all in a common plane, the first and last guides in each bank constituting terminal guides, and being disposed along a central path common to all banks, the middle roll in each bank being arranged to deflect the wire strand, as it passes, from the central path defined by the several terminal rolls, the several banks being arranged along such path and in different planes radially about that path, two of said banks, constituting the primary bending banks, being arranged angularly less than 180° one relative to the other, and to lie approximately equiangularly at opposite sides of the plane of the strand's coil, and each for deflection of the strand generally but not directly oppositely to its initial set, means in each bank to adjust the position of each deflecting roll transversely of the central strand path, and means common to all banks for simultaneously and in the corresponding sense adjusting the position of the deflecting rolls in all banks.

15. A wire straightener comprising a plurality of banks of wire guides, each bank including at least three guides all in a common plane, the first and last guides in each bank constituting terminal guides, and being disposed along a central path common to all banks, the middle guide in each bank being arranged to deflect the wire strand, as it passes, from the central path defined by the several terminal guides, the several banks being arranged along such path and in different planes radially about that path, two of such banks, constituting the primary bending banks, being arranged angularly less than 180° relative one to the other, and to lie approximately equiangularly at opposite sides of the plane of the strand's coil, and each for deflection of the strand generally but not directly oppositely to its initial set, and at least one bank arranged to resist rotation of the strand about its own axis, under the influence of the partially sidewise deflection of one or both said primary bending banks.

16. A wire straightener comprising a plurality of aligned banks of grooved wire-guiding rolls, each bank including at least three rolls all in a common plane, the first and last guides in each bank constituting terminal guides, and being disposed along a central path common to all banks, the middle roll in each bank being arranged to deflect the wire strand, as it passes, from the central path defined by the several terminal rolls, the several banks being arranged along such path and in different planes radially about that path, two of said banks, constituting the primary bending banks, being arranged angularly less than 180° one relative to the other, and to lie approximately equiangularly at opposite sides of the plane of the strand's coil, and each for deflection of the strand generally but not directly oppositely to its initial set, and at least one bank arranged to deflect the strand generally oppositely to, but to a lesser degree than, the deflection produced by one or both said primary bending banks.

17. A wire straightener comprising a plurality of banks of wire guides, each bank including at least three guides all in a common plane, the first and last guides in each bank constituting terminal guides, and being disposed along a central path common to all banks, the middle guide in each bank being arranged to deflect the wire strand, as it passes, from the central path defined by the several terminal guides, and the several banks being arranged along such path and in different planes radially about that path, two of such banks, constituting the primary bending banks, being arranged angularly less than 180° relative one to the other, and to lie approximately equiangularly at opposite sides of the plane of the strand's coil, and each for deflection of the strand generally but not directly oppositely to its initial set, a final bank similar to the others, and means mounting said final bank for rotation to any degree about the strand's axis for counteracting any residual set in the strand.

18. A wire straightener comprising a plurality of banks of wire guides, each bank including at least three guides all in a common plane, the first and last guides in each bank constituting terminal guides, and being disposed along a central path common to all banks, the middle guide

in each bank being arranged to deflect the wire strand, as it passes, from the central path defined by the several terminal guides, and the several banks being arranged along such path and in different planes radially about that path, two of such banks, constituting the primary bending banks, being arranged angularly less than 180° relative one to the other, and to lie approximately equiangularly at opposite sides of the plane of the strand's coil, and each for deflection of the strand generally but not directly oppositely to its initial set, a final bank similar to the others, means mounting said final bank for rotation to any degree about the strand's axis for counteracting any residual set in the strand, and means to vary the degree of deflection of the strand in its passage through said final bank.

19. A wire straightener as in claim 11, characterized in that the two primary bending banks are disposed relatively at 90° one to the other, and further characterized in the provision of at least two additional banks, each being arranged generally oppositely to a different one of the primary bending banks.

20. A wire straightener as in claim 11, characterized in that the two primary bending banks are disposed relatively at 90° one to the other, and further characterized in the provision of at least two additional banks, each being arranged generally oppositely to a different one of the primary bending banks, and a final bank mounted for rotation about the strand's path, and means to fix said final bank in any rotated position necessary to remove any residual set in the strand.

21. A wire straightener as in claim 11, characterized in that the two primary bending banks are disposed relatively at about 120° one to the other, and characterized further by the provision of an additional torsion-resisting bank arranged relatively at about 120° to each of the two primary bending banks.

22. A wire straightener as in claim 11, characterized in the provision of at least one bank in addition to the two primary bending banks, the deflecting guide in said additional bank or banks being arranged for less forceful deflection of the strand, and means mounting each bank for rotation about the central path, to vary the plane of the individual deflections.

23. A wire straightener as in claim 12, characterized in the provision of five rolls in each bank, the two terminal rolls being of large radius and defining, with the terminal rolls of other banks, the central strand path, and including two inner rolls of small radius spaced apart at the same side of the strand as the terminal rolls, and offset from such path, in addition to the middle roll, of small radius, interposed between the two inner rolls, and disposed at the opposite side of the strand.

24. A wire straightener as in claim 12, characterized in the provision of five rolls in each bank, the two terminal rolls being of large radius and defining, with the terminal rolls of other banks, the central strand path, and including two inner rolls of small radius spaced apart at the same side of the strand as the terminal rolls, and offset from such path, in addition to the middle roll, of small radius, interposed between the two inner rolls, and disposed at the opposite side of the strand, and means to adjust said middle roll, only, in each bank, transversely of said two small inner rolls.

25. In a wire straightener, a wire bending bank comprising a frame, two grooved, coplanar, terminal rolls defining a wire strand path leading to and from the bank, two spaced-apart inner rolls, coplanar with the terminal rolls, and offset to the same side of such path, a middle roll coplanar with but at the side of the strand opposite the other rolls, a lever fulcrumed at a point offset from the axis of the middle roll, said middle roll being mounted upon said lever, and means to rock said lever to interpose said middle roll more or less between said two inner rolls, to vary the extent of deflection of the strand effected by its passage over said middle roll.

26. In a wire straightener, a wire bending bank comprising a frame, two grooved, coplanar, terminal rolls defining a wire strand path leading to and from the bank, two spaced-apart inner rolls, coplanar with the terminal rolls, and offset to the same side of such path, a middle roll coplanar with but at the side of the strand opposite the other rolls, means to guide and adjust said middle roll along a transverse path intermediate said two inner rolls, to vary the extent of deflection of the strand effected by its passage over said middle roll, and means mounting said frame for rotation to a plurality of adjusted positions angularly about such wire strand path.

27. In a wire straightener, a wire bending bank comprising a frame, two grooved, coplanar, terminal rolls of larger radius journaled therein and defining a wire strand path leading to and from the bank, two spaced-apart inner rolls also journaled in the frame, of smaller radius than said terminal rolls and offset from and at the same side of such path as the latter, and a middle roll of radius similar to that of the inner rolls, coplanar with but at the side of the strand opposite the other rolls, disposed intermediate said inner rolls to deflect the strand oppositely to its bend in passing over said other rolls.

28. The method of straightening coiled wire which comprises pulling the strand along a longitudinal path, in passage effecting an abrupt deflection having both lateral and reverse components relative to the coil's plane and curvature of set, respectively, and at a longitudinally spaced point in such path similarly effecting deflection having a reverse component relative to the coil's curvature of set, but an opposite lateral component relative to the coil's plane.

29. The method of straightening coiled wire which comprises pulling the strand along a longitudinal path, at one point in such path, and as the strand passes such point, effecting an abrupt deflection having a lateral component relative to the coil's plane and a reverse component relative to the coil's curvature of set, at another point in such path effecting a similarly abrupt deflection having a similar reverse component relative to the coil's curvature of set, but having an opposite and approximately equal component laterally of the coil's plane.

30. The method of straightening coiled wire which comprises pulling the strand along a longitudinal path, at points spaced along such path, and as the strand passes such points, effecting an abrupt deflection having a lateral component relative to the coil's plane and a reverse component relative to the coil's curvature of set, at another point effecting a similarly abrupt deflection having a similar reverse component relative to the coil's curvature of set, but having an opposite and approximately equal component laterally of the coil's plane, at another point effect-

ing a deflection having a component in the same direction as the coil's curvature of set, but less abrupt than the previously mentioned deflections.

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