E. JAMES.

MANUFACTURE OF FLEXIBLE METAL TUBING.

APPLICATION FILED OCT. 10, 1910.

1,243,179. Patented Oct. 16, 1917.

3 SHEETS—SHEET 1.

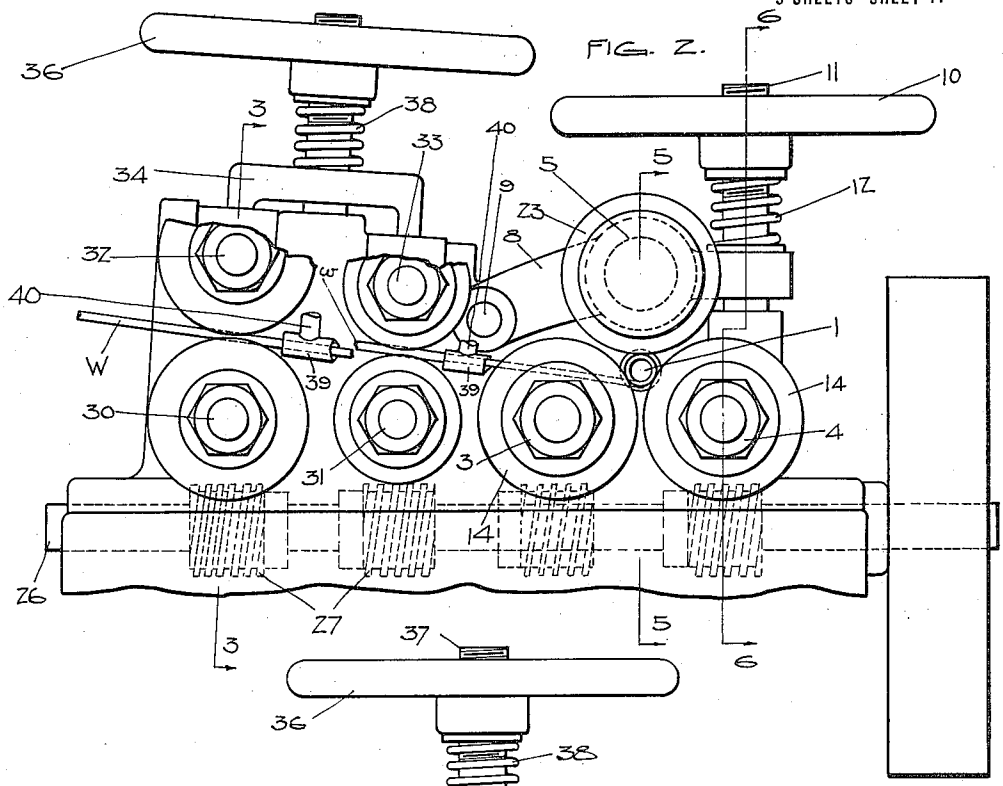


FIG. 2.

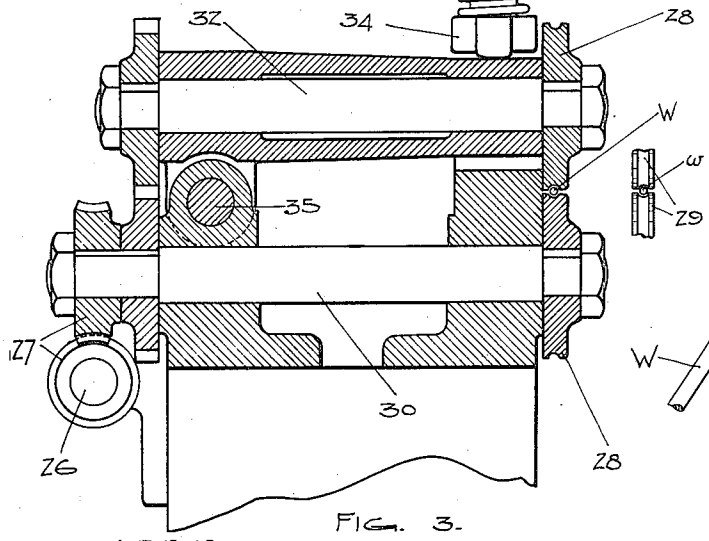


FIG. 3.

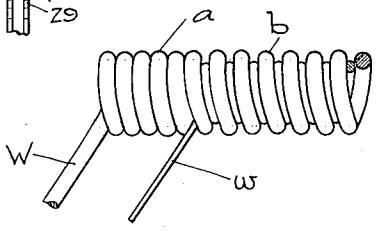


FIG. 1.

WITNESSES:

Myrtle K. Schuch.

Jno. F. Oberlin

INVENTOR

Edward James

BY J. B. Fay

ATTORNEY

E. JAMES.

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3 SHEETS—SHEET 2.

FIG. 6.

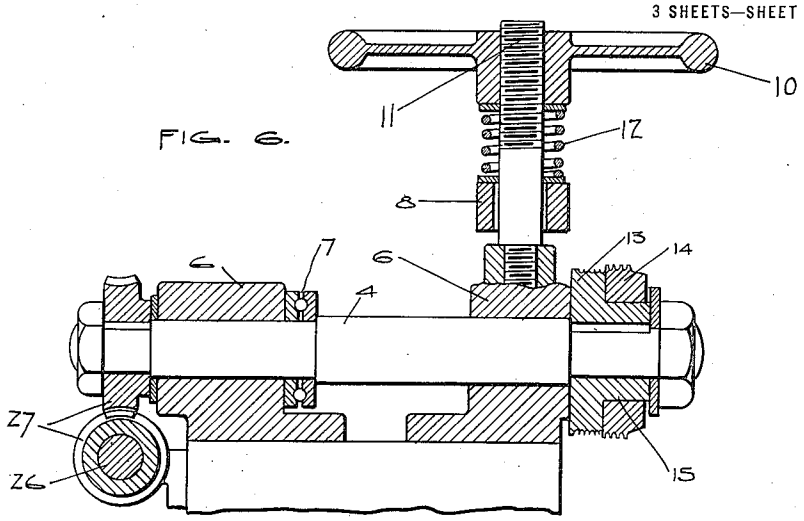


FIG. 5.

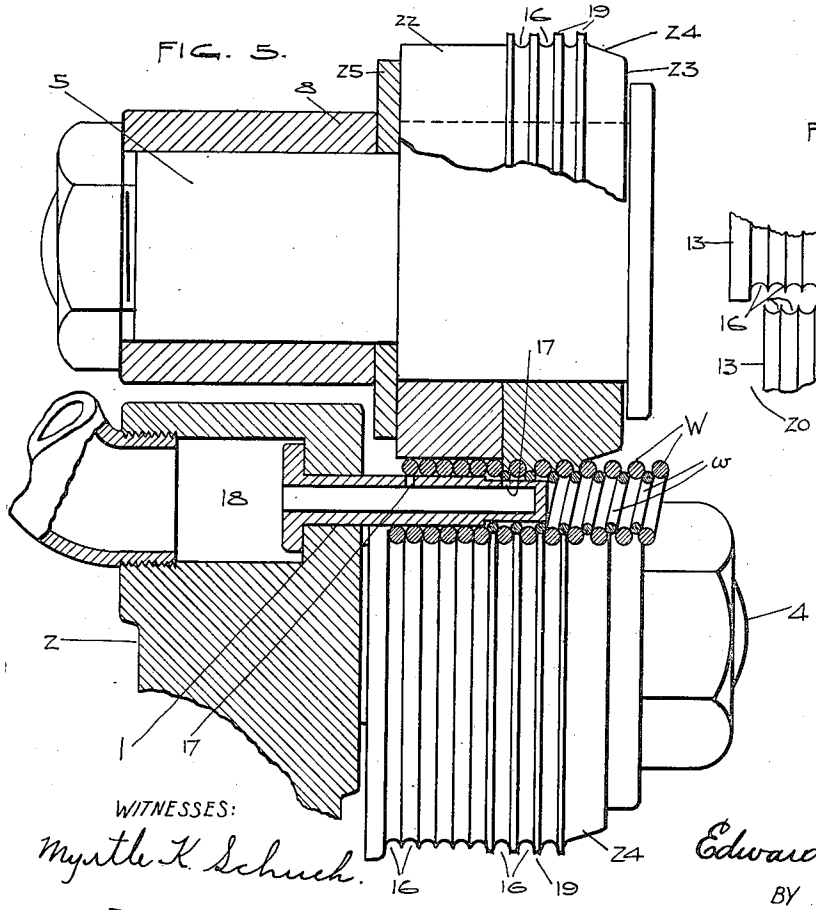
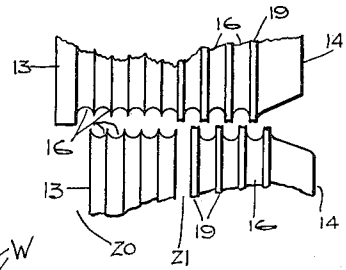


FIG. 4.



WITNESSES:

Myrtle K. Schuck.

Jno. F. Oberlin

INVENTOR

Edward James

BY J. B. Fay

ATTORNEY

E. JAMES.

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3 SHEETS—SHEET 3.

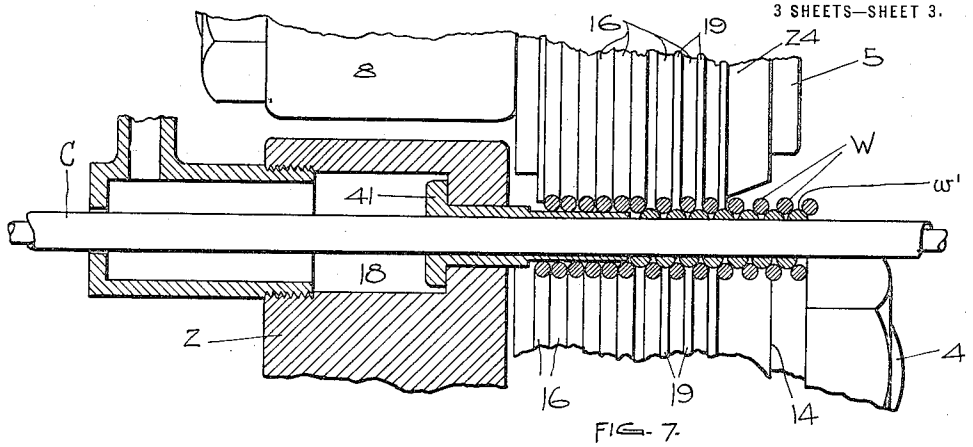


FIG. 7.

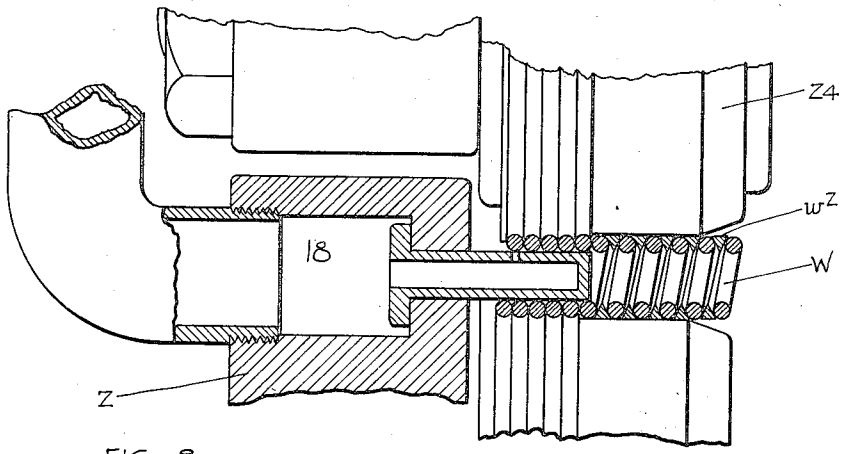


FIG. 8.

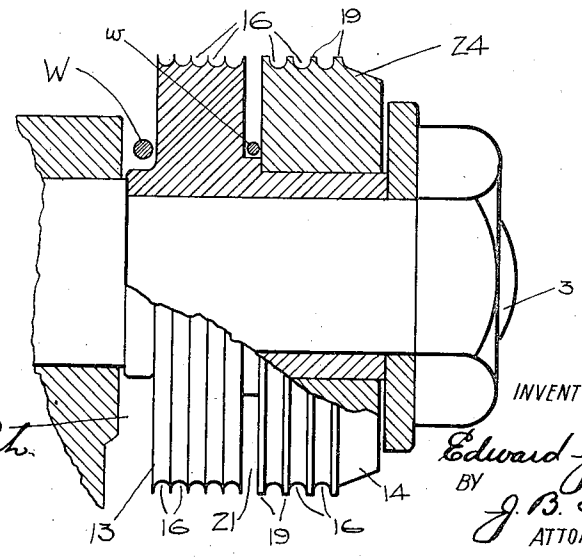


FIG. 9.

WITNESSES:

Myrtle K. Schuch.

Jno. F. Oberlin

INVENTOR

Edward James

BY

J. B. Fay

ATTORNEY

UNITED STATES PATENT OFFICE.

EDWARD JAMES, OF CLEVELAND, OHIO.

MANUFACTURE OF FLEXIBLE METAL TUBING.

1,243,179. Specification of Letters Patent. Patented Oct. 16, 1917.

Application filed October 10, 1910. Serial No. 586,157.

To all whom it may concern:

Be it known that I, EDWARD JAMES, a citizen of the United States, and a resident of Cleveland, county of Cuyahoga, and State of Ohio, have invented a new and useful Improvement in Manufacture of Flexible Metal Tubing, of which the following is a specification, the principle of the invention being herein explained and the best mode in which I have contemplated applying that principle, so as to distinguish it from other inventions.

My invention pertains to the manufacture of flexible metal tubing consisting of inner and outer coils of wire having their convolutions alternating, that is, the convolutions of the inner coil interposed, or partially interposed, between those of the outer coil; and my primary object is to improve such manufacture and cheapen the cost thereof. In accordance with my improved method of manufacture, I simultaneously wind the inner and outer coils and interpose the convolutions of the inner coil between those of the outer coil during such simultaneous winding. It is possible, by this method, to carry on a continuous operation and produce any desired length of flexible tubing, both of which objects are of the utmost importance, affecting, as they do, both the character of the product and the cost of manufacture. I may, in practising the invention, instead of winding such wires in place on a mandrel of the length of the coil and thereby limiting the length of the coil and thus of the tube, wind the wires on a mandrel, or equivalent forming member, that does not necessarily have a longitudinal movement so that no such limitation is imposed on the length of the tube that is formed. In other words, I am enabled to make tubing of the kind just referred to continuously, and of any desired length.

A further specific aspect of the present invention is the coiling of the wires, in the fashion previously described, directly onto an insulated conductor or the like in order to form what is known as an armored conductor, underwriters and others demanding nowadays that such conductors be thoroughly protected against injury to their insulation, as this is a frequent cause of fire in modern buildings. While my tubing may be formed independently of such insulated conductor or like product and the latter then slipped through, I have found it entirely practical to wind such tubing directly upon the conductor, thereby much facilitating and cheapening the cost of manufacture of the product.

To the accomplishment of the foregoing objects, then, said invention consists of the steps hereinafter fully described and particularly pointed out in the claims.

The annexed drawings illustrate one form of means whereby my improved method may be advantageously practised, and the following description sets forth in detail the preferred method of practising my invention.

In said annexed drawings:—

Figure 1 is a perspective view of a piece of tubing in course of formation; Fig. 2 is a side elevation of one approved construction of machine for carrying out the method of manufacture constituting the invention; Fig. 3 is a transverse sectional view thereof taken on the line 3—3, Fig. 2; Fig. 4 is a broken detail view, on a like enlarged scale, of two of said rolls; Fig. 5 is an enlarged sectional view of the mandrel and two of the rolls that coöperate therewith, the plane of the section being indicated by the line 5—5 Fig. 2; Fig. 6 is similarly a transverse sectional view taken on the line 6—6, Fig. 2; Figs. 7 and 8 are views, corresponding with Fig. 5, and respectively showing two modifications in the construction of the rolls; and Fig. 9 illustrates yet another modification in this particular.

In Fig. 1, W indicates the wire of the outer coil which is led in any desired manner and is coiled with its convolutions close together, this closely coiled portion being indicated by the letter *a*. At a desired point the convolutions of the coil of wire W are separated and a wire is introduced, as at *b*, and the convolutions of the wire *w*, as it is coiled, are forced between the convolutions of the outer coil W.

The coiling mechanism proper of the form of machine just referred to as particularly designed for use in my improved method of manufacture, comprises in the form illustrated, a short mandrel 1, (Figs. 2 and 5) that is preferably rotatably mounted in a suitable supporting head 2. It is not intended to positively drive such mandrel, however, but simply to leave it free to rotate under the action of the coil being formed thereon. Said mandrel, in the form shown in the figures just referred to, comprises two

co-axial, substantially cylindrical sections of unlike diameters, the section nearest to the head 2, or in other words, adjacent to the supported end of the mandrel, being of larger diameter than the free end.

Said mandrel is furthermore desirably made hollow, so as to be adapted to permit of the introduction therein of a suitable lubricant, which is preferably maintained under pressure sufficient to cause it to be gradually discharged through openings 17, 17 in the mandrel's cylindrical walls. Such lubricant may be thus supplied through a chamber 18 in the head 2, that provides a convenient reservoir. For many uses it has been found desirable to interiorly lubricate the type of flexible metal tubing, consisting of inter-coiled wires, such as the present machine is adapted to manufacture not only that the bore of such tube may be thus coated, but also the bearing or contacting portions of the successive convolutions of the inter-coiled wires. By the foregoing construction, enabling as it does, the introduction of the lubricant and its thorough spread within the convolutions of the coils formed on the respective sections of the mandrel, both of these desirable results are accomplished simultaneously with the winding of the coils.

Symmetrically disposed about such mandrel, and parallel therewith, are three shafts 3, 4 and 5 the two lower of which (viz. shafts 3 and 4) are preferably journaled in spaced fixed bearings 6, 6 while the uppermost is supported in a frame 8 oscillatory about an axis 9 parallel with the shaft, but capable of supporting said shaft at an adjustable distance above the mandrel 1, this distance being gaged by a hand wheel 10 threaded upon a vertically disposed screw 11, and bearing upon the free end of said frame through an interposed compression spring 12.

In addition to bearings 6, 6 for the shafts 3 and 4, I provide thrust bearings 7 (Fig. 6), to take up any end thrust to which such shafts may be subjected incidentally to the operation of the wire-coiling rolls respectively carried thereby.

The function of these rolls is to guide the respective wires W and *w*, that enter into the making of the tubing, about the mandrel 1 as well as to maintain them in contact therewith. Of such rolls the two lowermost are of substantially similar construction, viz., that shown in Figs. 4, 5 and 6, being composed of two sections, 13 and 14, the first being keyed or otherwise fixedly secured to its shaft, and the other being freely rotatable about such shaft, preferably upon a hub-like extension 15 of the first section. Both these sections are peripherally grooved, so as to provide on their outer, cylindrical faces a series of corrugations 16 concentric with the roll's axis, one form of corrugation being shown in Figs. 4 and 5. These particular encircling corrugations are designed to engage with the turns of the wire W being coiled on the mandrel section of larger diameter. Accordingly on the portions of the respective rolls that coöperate with the mandrel section of larger diameter such corrugations are more closely spaced axially of said rolls, than on the other portions of such rolls which extend beyond the offset or step between the mandrel sections of larger and smaller diameter. In other words, the corrugations on the first roll section 13, correspond with the closely crowded turns or convolutions of the first coil W as it is wound on the first mandrel section, whereas the convolutions on the second roll section correspond with the spaced condition of such convolutions after the second coil has been introduced within the first.

The second, or outer, roll-section 14, then, is provided with elements or ribs 19 lying intermediate between the corrugations 16 just described, which elements are at a greater radial distance from the roll's axis than the corrugations so as to contact with the convolutions of the inner coil *w*, that is introduced at this stage of the operation. Preferably, moreover, such elements or ribs of the roll are likewise grooved, so as to present corrugations, the more effectively to contact with and form these last-named convolutions. This, however, is not essential and such ribs on the second roll section may be left straight if desired, as shown for example in Fig. 9.

Between the two lowermost coiling rolls thus described as substantially identical, there exists this difference, viz., that the foremost roll, regarding the same in the direction in which the wire is fed, is cut away on its inner side, or otherwise spaced from the abutting portion of the machine frame, as by the introduction of a washer or disk of suitable thickness, so as to leave a space 20, (see Figs. 4 and 9) through which the wire W that forms the outer coil, may pass directly on a line from its corresponding feed rolls to the mandrel; that is to say, on a line tangent to such mandrel, as clearly shown in Fig. 2. It will be observed, in other words, that if such wire were fed in over the coiling roll to the mandrel, an extra bend, or kink, would be introduced in the wire, and that, too, in a direction opposite to the one which it is to receive upon being coiled on the mandrel. This result will follow no matter from what direction the wire be brought in between the rolls. By the arrangement just described however, I avoid this entirely and thus save the wire the additional strain that would be imposed upon it by being twice bent upon radii so short and close together.

Similarly a space 21 is left between the two sections 13 and 14 of this foremost roll, through which the second wire *w* may pass directly on a line tangent to the mandrel, thus avoiding kinking it likewise.

The upper roll of the three coiling rolls is illustrated as being simply an idler; but just as in the case of the two previously described, is formed of two sections 22 and 23 (see Fig. 5). Since this roll is utilized in the present machine merely to press down upon the coils of wire being formed about the mandrel by the two positively driven coiling rolls, I have found it advisable to dispense with corrugations on at least the first section 22 of such roll, inasmuch as a roll with a smooth surface will be just as effective to hold the convolutions of the initially formed portion of the outer coil against the mandrel as would a corrugated roll. The second section 23 may likewise be left plain if desired, although, here, in order to assist in spreading apart the convolutions of the outer coil, thus initially formed closely together, I prefer to employ the corrugations 16 with the raised intermediate ribs 19 adapted to coöperate with the inner coil that is now introduced.

The outwardly directed edges 24 of all three rolls, moreover, that is the edges directed away from the head 2, and in the direction of discharge of the finished tubing, are beveled as indicated in Fig. 5, since I have found that thereby the quick recoil of the wires, and particularly of the outer wire W, which otherwise follows the release of the tube from the coiling rolls, may be restrained and the tubing allowed to assume its normal condition as to internal tension, easily and gradually.

It will be understood, of course, that either the rolls or the encircling corrugations thereon are set relatively to each other so that the first corrugation that receives the wire will be a little in advance, (or in the rear as one may be pleased to regard it), of the second corrugation, and so on, in order that a proper spiral may be formed. (See Fig. 4.) Where three symmetrically disposed rolls are utilized, as in the present construction, there will be a displacement in the corrugation of successive rolls equal to one-third of the pitch of such spiral, as will be readily apparent. I prefer to secure the offsetting in question by correspondingly offsetting the entire roll, since this is readily accomplished by simply interposing a washer 25 of the proper thickness between the rear edge of the roll and the head or frame in which its shaft is journaled.

Of the three shafts hereinbefore described as bearing the wire-coiling rolls, the two lowermost along with certain feed-rolls 28 and 29 presently to be described, are driven in unison from a common drive-shaft 26 (Figs. 2, 3 and 6), preferably by means of worm gearing 27, although this obviously is a matter of indifference. The intermediate roll, viz., the one carried in the adjustable frame 8 above the mandrel, is preferably not positively driven, as this has been found unnecessary under ordinary operating conditions. It will be readily understood how it can be connected to be positively driven, if desired, from the same shaft as the other two rolls, or from a counter-shaft connected therewith.

There are two pairs of the feed rolls 28 and 29 just referred to, as shown in Fig. 2, such pairs of rolls being laterally spaced from each other so as to feed the wires W and *w* passing therebetween respectively, at the proper points longitudinally of the mandrel 1; in other words, the second wire is spaced from the first a distance substantially equal to the length of the mandrel section of larger diameter that projects beyond the mandrel supporting head 2, it being upon this section that the outer wire constituting the tube is initially wound before its convolutions are separated by the introduction of the second coil.

Of these two pairs of feed-rolls the lowermost rolls of each are mounted upon shafts 30 and 31, journaled in the frame of the machine and driven, as above indicated, from the main drive-shaft 26 that also drives the two lowermost of the wire-coiling rolls. The upper feed rolls are also positively driven, their shafts 32 and 33 being intergeared with the corresponding lower shafts. Such upper shafts, however, are journaled in a common movable frame 34, preferably one oscillatory about an axis 35 transverse to the shafts and adapted to be pressed down under a variable pressure by means of a hand-wheel 36 mounted upon a threaded shaft 37 and operating through an interposed spring 38 similar to that employed in connection with the uppermost coiling roll.

Intermediately between the respective pairs of feed rolls, that thus feed in the two wires used in forming the tube, and the coiling rolls, which wind such wires into tubular form, I provide tubes 39 of suitable length, through which the wires may pass. These tubes are designed to contain a suitable lubricant, preferably, one containing graphite as a constituent, which lubricant may be supplied as required through a feed opening 40 so that the wires as they are fed forwardly onto the mandrel, or rather into the coiling rolls, are thoroughly coated with the lubricant in question.

While in the preceding reference to the operation of my improved machine it has been implied that the wires are fed directly in between the mandrel and the coöperating coiling rolls this is in practice strictly true

only when once the machine has been put in operation. In other words, in order to start the machine, it is desirable to form apart from such machine, a short section of the tubing composed of one wire coiled within the other, so that this can be placed on the mandrel and the rolls closed thereon. The means whereby such short section of tubing is preparatorily formed are not of present interest, as they constitute no part of the invention in hand.

A modification of the mechanism hereinbefore described, whereby such mechanism is adapted to coil wire into a flexible metallic tube directly incasing an electrical conductor, or like conduit, is illustrated in Fig. 7 where it will be observed that the modified mandrel 41 comprises a single section of uniform diameter corresponding with the section of larger diameter in the case of the mandrel previously described. Such mandrel is furthermore open at both ends and the insulated conductor C, which is to be incased, is passed directly therethrough, the diameter of the mandrel bore being properly gaged to fit closely about the conductor. The latter thus replaces, in effect, the mandrel section of smaller diameter and the operation of intercoiling the two wires that go to make up my improved tubing, may proceed just as before, the outer wire being coiled upon the mandrel section of larger diameter that is retained, while the smaller wire is coiled upon the conductor. The latter, it will be understood, is allowed to move longitudinally through the mandrel as the inner wire is thus coiled thereon, thus differing from the mandrel section of smaller diameter in the preceding construction.

It is desirable as before, that the tube should be interiorly lubricated and to this end the reservoir 18 in the head 2 is constructed so as to permit the conductor to be drawn directly therethrough, it being found that sufficient lubricant will adhere thereto to effect the desired purpose. The proposition is obviously substantially the same where, instead of the insulated electrical cable, it is desired to armor rubber hose, or any similar object. My improved flexible metal tubing may be directly formed on such hose in exactly the same fashion as that in which I have just described it as being wound upon the insulated conductor. The term conductor, accordingly, will hereinafter be employed to connote either of these two products, or any similar product to which my tubing may be thus applied. I have furthermore found that where the coils are being wound on an insulated electrical conductor in the production of an armored conductor, such as just described, it is advantageous to so gage the diameters of the interlocking wire coils, that the convolutions of the inner one shall be more or less effectively embedded in the insulation of the conductor, since I am thus enabled to use a lighter gage of wire, while still providing an equally effective covering or armor for the conductor. In other words, the embedded coil will receive and take up a greater longitudinal strain for a given gage of wire than if it were the inner coil of a simple tube or of such a tube only loosely incasing the conductor.

A further modification is shown in the figure just referred to in that the inner, or smaller, wire w' as it has been previously termed, is of half-round section, instead of being a circular wire of smaller diameter than outer wire W. It will be understood, of course, that my improved machine is not limited to use with any particular cross-section of wire strand; but such strand may be either circular, or half-round, or angular, as may be found suitable to the production of tubing of the general class in hand.

Thus in Fig. 8, I illustrate the use, for one of the wires, of a strand w^2 of triangular cross-section, such strand, moreover, is here shown as being the outer one despite the fact that it is introduced at a point in the operation corresponding with the introduction of what has in the preceding cases figured as the interior coil. Accordingly the second section of the respective rolls is here left plain, that is, without corrugations and this second wire w^2 simply pressed into place, correspondingly spreading the turns of the interior coil. In this operation no mandrel section of smaller diameter is necessary and so it is accordingly omitted in the showing of Fig. 8.

It has been previously explained that the elements or ribs between the corrugations 16, in the case of the second or outermost sections 14 and 23 of the rolls, may be left smooth, that is, so as to present a cylindrical surface instead of being concave. The smooth superficial form of these ribs is illustrated in Fig. 9. On the other hand, were a strand w^2 of triangular section to be introduced as the inner coil in the way that strand w' is introduced in Fig. 7, these ribs might be made with an angular depression to fit the contour of the wire.

In each of the several forms of my improved machine illustrated in the drawings hereinbefore described there will be, owing to the use of the feed rolls, but little tension, if any, on the wires between such feed rolls and the coiling rolls. It will be understood, however, that in place of thus pushing the wires, as it were, upon the mandrel and simply employing the coiling rolls to bend the same onto such member, I might rely on the frictional engagement of the rolls with the turns of wire about the mandrel to pull the latter, thus making the coiling mechanism, proper, self-feeding.

Under certain operative conditions, moreover, the positive driving of the coiling rolls might be omitted entirely and full reliance placed on the feed rolls to force the wire or wires onto and about the mandrel.

Where the feeding of the component wires, the interposed convolutions of whose coils go to make up my improved tube, is accomplished by pushing such wires into the coiling members, whether rolls or dies, the use of the mandrel may be dispensed with. This is in effect exemplified in the construction shown in Fig. 7, where the second wire may be either pushed in, to directly surround the insulated cable so as to only lightly engage therewith, or where it may be drawn in about the same by the pulling action of the rolls; in the first case the presence of the cable will be only incidental, while in the second it will obviously function as a mandrel. In any case the rolls serve to apply a sufficient lateral pressure to the wire entering there-between, to form the same into coils with convolutions of the proper diameter; it being in a degree, immaterial whether a mandrel be located within the coil in order to thus determine its diameter, or the mere resilient tendency of the convolutions be depended upon to maintain as large a diameter as possible within the limits prescribed by such laterally applied pressure.

The foregoing detailed description has been given for clearness of understanding only and no undue limitation should be understood therefrom, but the appended claims should be construed as broadly as permissible in view of the prior art.

The term "coil" throughout the claims is intended to refer to the respective series of convolutions, and it is obviously immaterial whether the respective coils be formed by one wire or by a plurality of wires.

Other modes of applying the principle of my invention may be employed instead of the one explained, change being made as regards the process herein disclosed, provided the step or steps stated by any one of the following claims or the equivalent of such stated step or steps be employed.

I therefore particularly point out and distinctly claim as my invention:—

1. The method of manufacturing a product of the character described, which consists in winding a coil with close convolutions; spreading the convolutions of a wound portion of the coil, while continuing the winding of the coil; and, simultaneously with such spreading, winding a second coil and interposing its convolutions between the spread convolutions of the first coil.

2. The method of manufacturing a product of the character described, which consists in winding a coil with close convolutions; spreading the convolutions of a wound portion of the coil, while continuing the winding of the coil; and, simultaneously with such spreading, winding an inner coil and interposing its convolutions between the spread convolutions of the outer coil.

3. The method of manufacturing a product of the character described, which consists in winding a coil; and, while continuing the winding of the first coil, winding a second coil and forcing its convolutions into interposition between the convolutions of the first coil in the winding operation.

4. The method of manufacturing a product of the character described, which consists in preparatorily forming two coils on the ends of wires, with the convolutions of said coils interposed, and then rotating said interposed convolutions relatively to the wires so as to coil said wires and force the convolutions of one coil between those of the other as they are thus formed.

5. The method of manufacturing a product of the character described, which consists in preparatorily forming inner and outer coils on the ends of two wires, with the convolutions of said coils interposed, and then rotating said interposed convolutions relatively to the wires so as to coil said wires and force the convolutions of the inner between those of the outer coil as they are thus formed.

6. The method of manufacturing a product of the character described, which consists in winding a coil of wire of circular cross section; spreading the convolutions of the wound coil; and simultaneously with such spreading, winding a second coil of wire of smaller diameter than said first wire and interposing its convolutions between the convolutions of the first coil the cylindrical plane of the inside surfaces of the second coil between within and spaced from the cylindrical plane of the inside surfaces of the first coil.

Signed by me, this 3rd day of October, 1910.

EDWARD JAMES.

Attested by—
ANNA L. GILL,
JNO. F. OBERLIN.