

June 26, 1934.

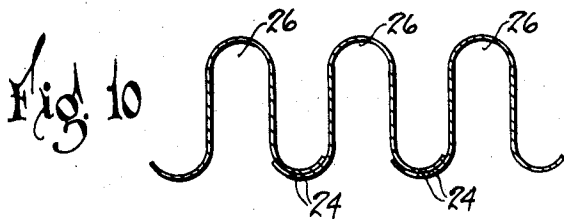
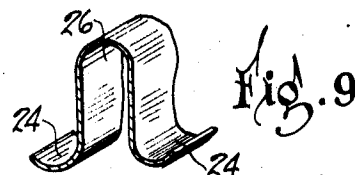
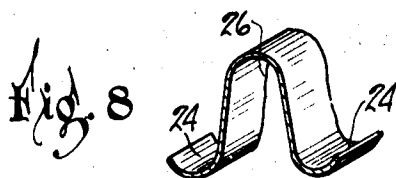
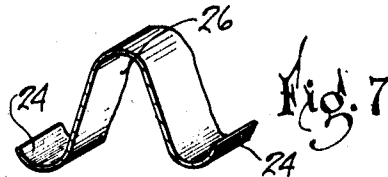
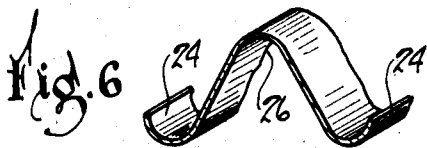
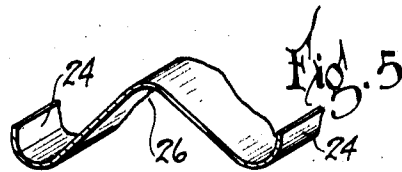
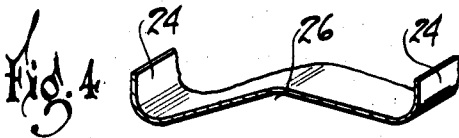
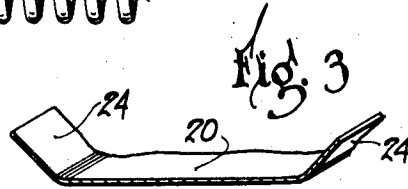
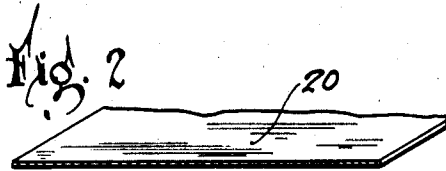
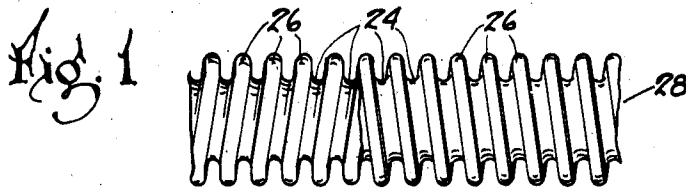
C. C. HARRAH

1,964,289

MANUFACTURE OF CONDUITS

Filed Sept. 28, 1933

3 Sheets-Sheet 1



INVENTOR.
Clayton C. Harrah
BY J. W. Womack
ATTORNEY.

June 26, 1934.

C. C. HARRAH

1,964,289

MANUFACTURE OF CONDUITS

Filed Sept. 28, 1933

3 Sheets-Sheet 2

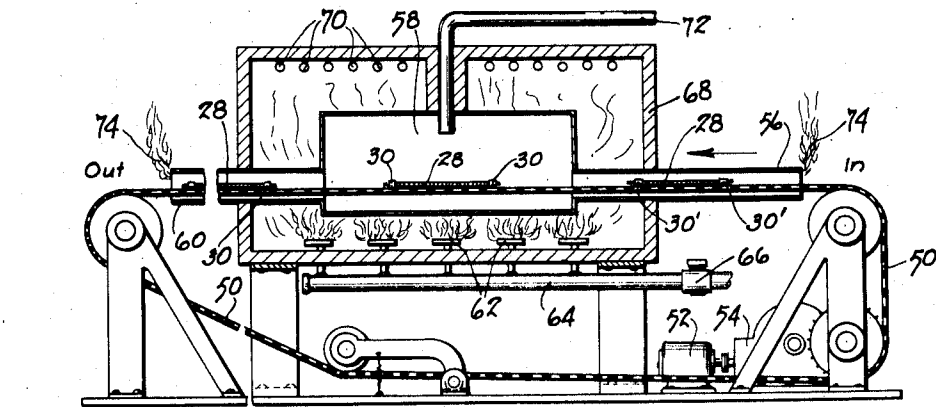
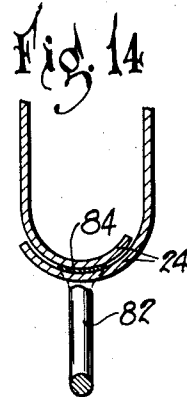
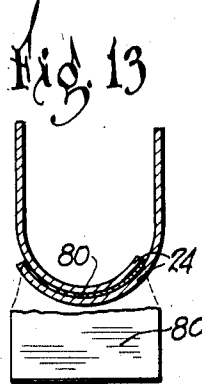
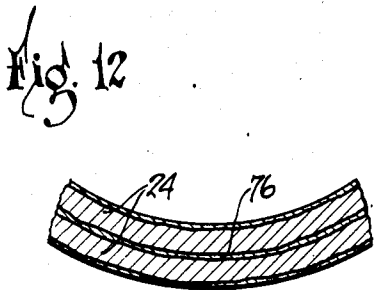
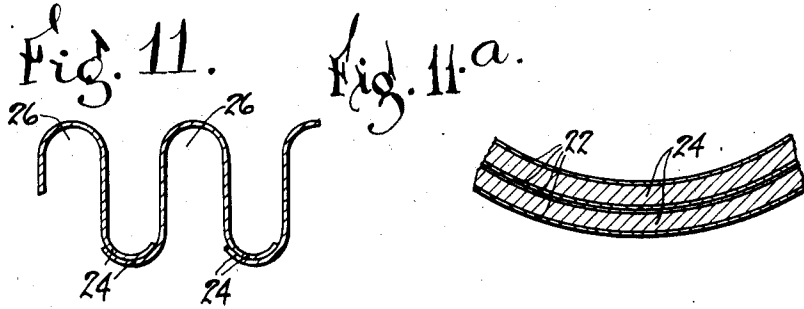


Fig. 15

INVENTOR,
Clayton C. Harrah

BY

W. W. McAnker
ATTORNEY.

June 26, 1934.

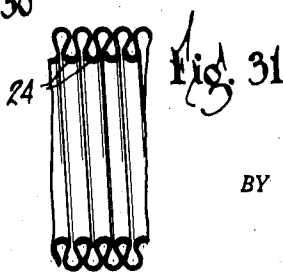
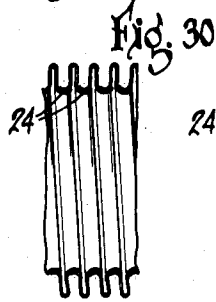
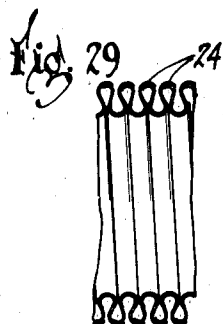
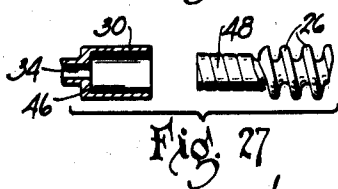
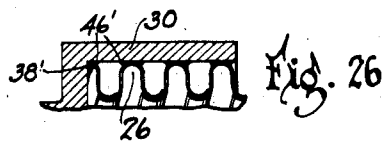
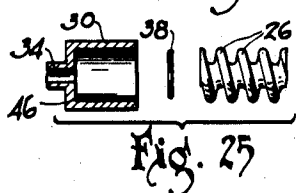
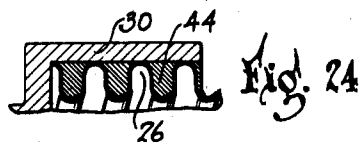
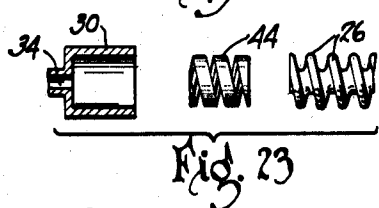
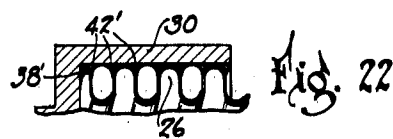
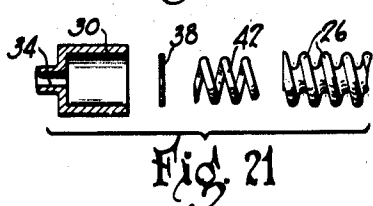
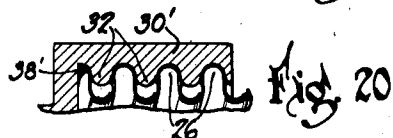
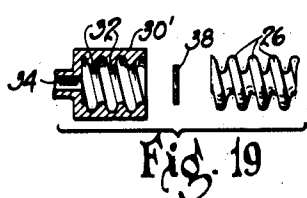
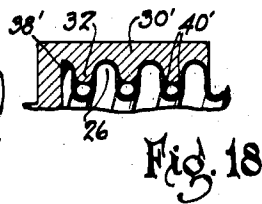
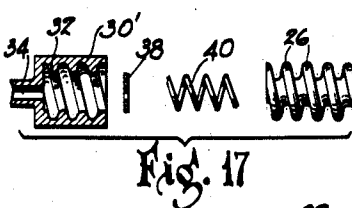
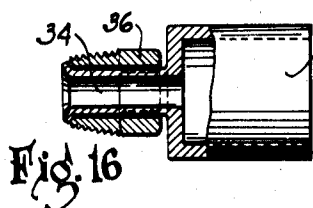
C. C. HARRAH

1,964,289

MANUFACTURE OF CONDUITS

Filed Sept. 28, 1933

3 Sheets-Sheet 3



INVENTOR.
Clayton C. Harrah

BY

W. W. W. W.
ATTORNEY.

UNITED STATES PATENT OFFICE

1,964,289

MANUFACTURE OF CONDUITS

Clayton C. Harrah, Niles, Mich., assignor to
National Standard Company, Niles, Mich., a
corporation of Michigan

Application September 28, 1933, Serial No. 691,345

5 Claims. (Cl. 29—157)

This invention relates to the manufacture of conduits, and is illustrated as carried out in the manufacture of a jointed type of spirally-corrugated flexible steel conduit.

6 An object of the invention is to provide an inexpensive method of manufacturing a strong but light conduit. The conduit is preferably flexible, and includes a spiral metal strip, preferably of steel, having the margins of adjacent
10 convolutions permanently united by a joint of relatively large area which will not be weakened by continued flexing and which is substantially as strong as the rest of the conduit.

This object is attained, in accordance with the
15 present invention, by rolling the strip to form in it a central longitudinally-extending corrugation, and then winding it under considerable tension spirally over a mandrel or the like to cause the margins of adjacent convolutions to overlap to
20 a substantial degree, e. g. about 120° of the curvature at the bottom (or top) of the corrugation. This forms a double-thickness corrugation facing the opposite direction from the corrugation which is rolled integrally into the strip, with the
25 overlapping portions held together by a very considerable tension on the strip.

A hard metallic bonding material such as copper, brass, silver alloy, or the like, is provided
30 between the overlapping margins described above, and is compressed by the tension on the joint so that this material (which is relatively soft compared to steel) is squeezed down completely to fill the space between the overlapping margins and form a metallic seal therebetween.
35 The copper or other metal may be provided as a separate strip or wire, or preferably as a plating on the steel.

While the conduit so formed is satisfactory for some purposes, one of the objects of my invention
40 is to convert this seal into a strong permanent bond or joint interlocked with the structure of the steel, to give a joint capable of withstanding very high pressures, the resulting conduit being comparable in strength and durability and
45 flexibility to the much more expensive corrugated flexible conduits made from seamless tubing.

To this end, the conduit prepared as described above is highly heated in a non-oxidizing atmosphere, for example by passing it through a hydrogen furnace, and then slowly cooling it also in the non-oxidizing atmosphere. This step simultaneously does two things, which are much more
50 satisfactory when done at once in the described manner than when done in separate steps.

First, the copper or other bonding material in the joint melts and seeps into the structure of the steel of the overlapping margins, forming throughout the entire overlapping area a strong
60 metallic bond or joint which is entirely free of gaps or leaks or weak places, and which in the finished conduit is substantially as strong as the steel itself, making it possible to use the conduit with internal pressures running up to several
65 thousand pounds per square inch.

This has previously been possible only with
70 seamless corrugated conduit, which is much more expensive and which can only be made in short lengths, and which must be made heavier than is necessary with my conduit because the drawing of the metal in forming the corrugations (as compared with the rolling or folding operation I perform on the steel strip) greatly thins the metal at the bottom of the corrugation, just
75 where it should be the strongest and just where it is of double thickness in my conduit.

Second, the steel is annealed, to relieve it of internal stresses and strains, including the tension which holds the joint together while the joint is being formed as described above. It will be appreciated that this tension is objectionable
80 in using the conduit for many purposes, as it gives it a tendency to twist. At the same time it is necessary in holding the joint tight before the fusing of the copper or other metal, as the joint cannot be successfully made if there is any substantial gap (i. e. more than .0015 inch) across which the metal is expected to flow. Thus the tension is provided as long as needed, but is completely eliminated in the finished product.

For many uses of the conduit, I also prefer
85 to perform in the furnace, simultaneously with the operations described above, the additional operation of permanently attaching to the conduit one or more suitable fittings. The fitting is preferably seated over the end of the conduit,
90 with metal bonding material between it and the conduit, so that the heating in the furnace forms a strong and tight joint of considerable area between the fitting and the conduit. This joint, being formed simultaneously with the joint between the overlapping margins of the spiral steel strip, is in effect continuous with that joint, thus obviating any possibility of leakage past that joint where it enters the fitting.

I prefer to form the fitting with internal
105 threads, so that it may be threaded onto the convolutions at the end of the conduit. If desired, a helical metal wire coil or the like may first be threaded over those convolutions, to come between them and the threads of the fitting, to
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insure an ample supply of bonding material for the joint. I also usually prefer to place a copper or other metal washer in the bottom of the recess in the fitting, to insure a tight joint between the bottom of the recess and the end surface of the conduit.

In most cases, the conduit is compressed or collapsed endwise, to close up the corrugations as much as possible and thereby give maximum flexibility.

While it is believed that my novel method will be clear from the foregoing description, I have shown in the accompanying drawings one illustrative sequence of operations for carrying it out. In these drawings:

Figure 1 is a view of the conduit as it goes into the furnace, being partly in side elevation and partly in longitudinal section;

Figure 2 is a perspective view of the end portion of the steel strip from which the conduit is made;

Figures 3, 4, 5, 6, 7, 8, and 9 show successive steps in rolling the corrugation into the strip, after which it is wound spirally into the form shown in Figure 1;

Figure 10 is an enlarged sectional view showing the manner of overlapping the margins of adjacent convolutions;

Figure 11 is a view like Figure 10;

Fig. 11a shows a small section of the joint of Fig. 11 much magnified;

Figure 12 is a view, after the heating operation in the furnace, of the magnified section of Figure 11, and showing the finished joint;

Figure 13 is a diagrammatic sectional view illustrating the introduction between the overlapping margins of a copper strip, instead of using copper-plated steel for the strip as in Figures 1-11;

Figure 14 is a similar diagrammatic sectional view showing the introduction of a copper wire instead of a copper strip;

Figure 15 is a longitudinal vertical section through a hydrogen furnace, showing the heating operation;

Figure 16 is a view, partly in side elevation and partly in section, of one type of fitting adapted to be used on the conduit;

Figure 17 shows in section a modification of the fitting having an internal thread with the helical copper wire coil and the copper washer referred to above, together with the end of the conduit;

Figure 18 shows in section the parts of Figure 17 assembled, after removal from the furnace;

Figures 19 to 28 inclusive are pairs of views showing modifications of the fittings, the views of each pair corresponding to Figures 17 and 18 respectively; and

Figures 29, 30, and 31 are sections through finished conduits, after the operation of compressing or collapsing them endwise:

In the illustrated sequence of operations, a strip 20 of steel (Figure 2), preferably plated with a bonding material such as copper, brass, silver alloy, or the like, to form layers 22 (Figure 11) on its opposite faces, is run through a series of rolls to form it as illustrated in Figures 3 to 9 inclusive. This may be done in the machine described and claimed in copending application No. 695,270, filed October 26, 1933.

In the first of the illustrated steps, the margins 24 are folded up at an angle to the strip and then a central longitudinal corrugation 26 is gradually deepened along the center of the

strip, while the margins 24 are curved to form in effect half-corrugations, preferably extending about 120°.

The strip so corrugated is then wound spirally, for example on a mandrel as described in my above-identified copending machine application, to overlap the margins 24 (as shown in Figures 10 and 11) under a very substantial tension which compresses the relatively soft copper or other metal bonding material to form a tight seal in the joint, thereby forming the conduit 28 shown in Figure 1. This conduit may itself be used for some purposes, but I prefer to continue the manufacture as described below.

The above-mentioned machine application also described the use of the mandrel and rolls to vary the curvature of the strip during the winding operation. By the use of this or other means, the diameter of the conduit may be varied, either progressively on a taper or by stages to produce integrally-connected sections of different diameters.

As explained in my copending application No. 691,344, filed Sept. 28, 1933, and covering the finished conduit as an article of manufacture, the overlapping margins 24 may come either at the bottom of the inwardly-extending outwardly-facing corrugations of the conduit 28 as shown for example in Figures 1, 30, and 31, or at the top of the outwardly-extending inwardly-facing corrugations as shown for example in Figure 29, or even in some cases in the side walls of the corrugations. The method of manufacture is in all these cases substantially the same.

The conduits are next preferably provided with fittings 30 or 30', as shown in Figures 16 to 28. These fittings are preferably of steel, or they may be of brass or bronze or other metal, and they differ principally in that the fitting 30 has a smooth-surfaced recess embracing and sleeved over the end of the conduit, while the fitting 30' is formed with an internal thread 32 which is threaded over the end of the conduit as shown in Figures 18 and 20. The fittings may have attaching means such as stems or tubes 34, spun over at their ends to hold thereon attaching nuts 36 or the like.

In the arrangement shown with the parts separated in Figure 17, and after removal from the furnace in Figure 18, a copper washer 38 is seated in the bottom of the recess in the fitting and is abutted by the end of the conduit. A helical coil of copper wire 40, shown round in cross-section, is threaded into the convolutions of the conduit at its end, and the fitting 30' is then threaded on over the wire. After the attaching operation, the copper flows mainly into the spaces where the fitting and conduit approach or engage each other, as shown at 38' and 40', giving a permanent metallic bond or joint throughout the greater part of the overlapping areas of the fitting and conduit, a joint which is moreover continuous with the joint between the overlapping margins 24.

The construction illustrated in Figures 19 and 20 is substantially the same except that the wire 40 is omitted, and the joint therefore is not quite so thick in the groove between the threads and the corrugations.

In Figures 21 and 22, the space between the convolutions 26 and the smooth wall of the recess in fitting 30 is almost filled by a helical coil 42 of wire preferably of circular or oval cross-section, which is threaded over the convolutions, the fitting 30 then being sleeved thereover. The

washer 38 may be provided, if desired, as described above. Here also in the finished article substantial joints 38' and 42' are formed in the overlapping parts of the fitting and conduit and also in the converging spaces adjacent these portions.

In Figures 23 and 24, the construction may be the same as in Figures 21 and 22, except that the helical copper wire of the coil 44 is of a special cross-section (somewhat U-shaped) completely to fill the space between the convolutions 26.

In Figures 25 and 26, the smooth interior of the recess in the fitting 30 is provided with an internal plating or bushing 46, and is sleeved directly on the end of the conduit, with a washer 38 if desired. In this form the joint will only be along the tops of the convolutions 26, as shown at 46', but for many purposes this is sufficient.

The construction of Figures 27 and 28 is like that of Figures 25 and 26, except that the convolutions 26 are flattened down to form elongated flat-topped loops 48 which fit snugly into the recess in the fitting.

Whichever method of attaching the fitting 30 or 30' is adopted, after the above-described parts are assembled the conduit 28 is next passed through a furnace in which it is highly heated in a non-oxidizing atmosphere. One form of such furnace is illustrated in Figure 15.

In the particular furnace illustrated, conduits 28 are carried slowly, by means such as a chain or metallic belt conveyor 50, shown driven by an electric motor 52 through reduction gearing 54, through an entrance tube 56, into and through the furnace space proper 58, and thence out through an exit tube 60 which is long enough so that the conduits are too cool to oxidize by the time they come out of it into the atmosphere.

The furnace 58 is highly heated, for example by gas burners 62 fed by a gas line 64 and controlled by a valve or the like 66. An insulated housing 68 for the burners 62 surrounds the furnace 58, and has suitable exhaust passages 70, which may lead to a stack or the like (not shown).

A non-oxidizing (and preferably a reducing) gas such as hydrogen is introduced into the furnace 58 through a suitable conduit 72, under a light pressure sufficient to insure that no air will enter through tubes 56 and 60. This causes the gradual loss of some of the hydrogen through tubes 56 and 60, the hydrogen so lost burning quietly in flames 74 at the ends of the tubes.

It will be seen that, by highly heating and then cooling the conduits in a non-oxidizing atmosphere in the manner illustrated, two main operations, and if desired a third auxiliary operation, are performed simultaneously, and that moreover the results are greatly superior to the results that would be secured by performing these operations as separate steps.

First, the copper or other bonding material between the overlapping margins 24 melts and penetrates the structure of the steel on both sides, while that structure is opened up by the heat. This forms a very strong permanent joint 76 (Figure 12), substantially integrally uniting the margins 24 throughout their entire overlapping areas.

Second, the steel is annealed, to eliminate all internal stresses and strains, and particularly the tension which holds the margins 24 together until the above-described permanent joint 76 is formed. It will be appreciated that a substantial tension in the steel is necessary to hold the margins 24 tightly together while the joint is being formed, as it is difficult to form a metallic

brazed joint of this character if the metal has to flow past any gaps, a maximum of .0015 inch or less being desirable as the greatest space between the margins 24 to be bonded together. At the same time, for many purposes such a spiral tension is undesirable in the finished conduit.

Third, the fittings 30 or 30' are permanently attached by a joint which is as strong as the conduit itself, and which (being formed at the same time) in effect is continuous with the joint between the overlapping margins 24, so that there is no possibility of gaps or leaks where that joint passes into the fitting.

The tube so formed, after cooling, is finally compressed or collapsed endwise to the form shown in Figures 29-31, to give it maximum flexibility.

In Figure 29, the overlapping margins 24 are on the outside, and they are overlapped approximately 120°, in which case the convolutions collapse axially substantially uniformly as shown.

In Figure 30 the margins 24 are on the inside of the corrugations and are somewhat longer than 120°, so that they do not collapse as readily as the single-thickness portions opposite them. In this case the inwardly-facing corrugations are much narrower than the outwardly-facing ones, and in fact have their walls normally almost in contact.

In Figure 30, the construction is the same as in Figure 29, except that the joint between the overlapping margins 24 comes at the bottom of the outwardly-facing inwardly-extending corrugations.

While ordinarily this step of axially compressing or collapsing the conduit is performed after it has been treated in the furnace, it may sometimes be desirable to perform this step before the conduit is placed in the furnace.

As shown in Figure 13, instead of using copper-plated steel, a strip 80 of copper or other bonding metal may be fed directly between the margins 24 while the conduit is being wound. Or, as shown in Figure 14, a copper or other metal wire 82 may be used; in this case the wire is flattened by the winding operation into a ribbon 84 between the margins 24.

While one particular sequence of steps has been described in detail, it is not my intention to limit the scope of my invention to that particular sequence, or to the utilization of all of those steps, or otherwise than by the terms of the appended claims. It is not my intention to claim in the present application any subject-matter claimed in my above-identified copending applications on the machine and on the completed conduit.

I claim:

1. That method of making a flexible conduit which comprises corrugating a strip of metal plated with a bonding material such as copper, winding said strip spirally under tension with the margins of adjacent convolutions overlapping for a considerable area, placing on the end of the conduit a fitting which is sleeved over the end of the conduit and with bonding material between the conduit and said fitting, and heating said conduit to a high temperature in a non-oxidizing atmosphere and then cooling it, to accomplish simultaneously the operations of (1) annealing the metal to relieve it of said tension as well as other stresses and strains, (2) forming a joint between said margins throughout their overlapping areas by the introduction of the bonding material into the structure of the metal of said margins, and (3) permanently at-

taching said fitting by a joint which is continuous with the joint between said margins and which consists of bonding material entering into the structure of the metal of the fitting and of the conduit.

2. That method of making a flexible conduit which comprises corrugating a strip of metal plated with a bonding material such as copper, winding said strip spirally under tension with the margins of adjacent convolutions overlapping for a considerable area, and heating said conduit to a high temperature in a non-oxidizing atmosphere and then cooling it, to accomplish simultaneously the operations of (1) annealing the metal to relieve it of said tension as well as other stresses and strains, and (2) forming a joint between said margins throughout their overlapping areas by the introduction of the bonding material into the structure of the metal of said margins.

3. That method of making a flexible conduit which comprises heating in a non-oxidizing atmosphere a spirally wound longitudinally-corrugated strip having the margins of adjacent convolutions overlapping and under tension so the overlapping margins press against each other and with a bonding metal between said overlapping margins, simultaneously to anneal the conduit whereby said tension is relieved and to unite said margins throughout their overlapping areas.

4. That method of making a flexible conduit which comprises heating a spirally wound longitudinally-corrugated strip having the margins of adjacent convolutions overlapping and under tension so the overlapping margins press against each other and with a bonding metal between said overlapping margins, simultaneously to anneal the conduit whereby said tension is relieved and to unite said margins throughout their overlapping areas, and simultaneously therewith permanently attaching to said conduit a fitting by a metallic surface bond formed by said heating step.

5. That method of making a flexible conduit which comprises longitudinally corrugating a metal strip, winding said strip spirally under tension with the margins of adjacent convolutions overlapping for a considerable area and with a bonding material of lower melting point than the metal of the strip between the overlapping margins, heating said conduit so spirally wound to a temperature high enough to melt the bonding material and to open the structure of the metal strip to receive the melted bonding material, and then cooling the strip to form a joint between the overlapping margins which penetrates substantially into the structure of the metal of said margins.

CLAYTON C. HARRAH.

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