

April 19, 1955

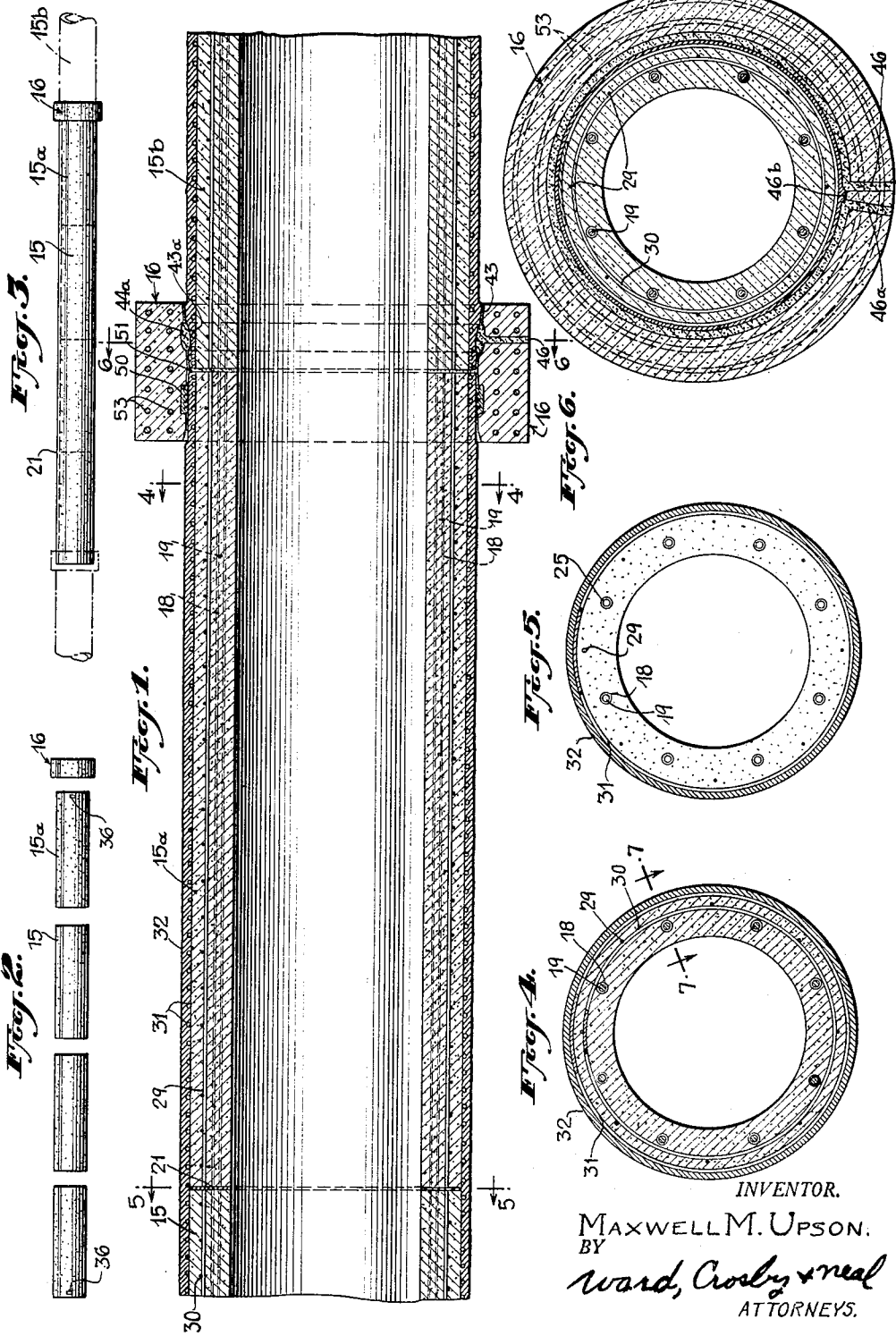
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2,706,498

PRESTRESSED TUBULAR CONCRETE STRUCTURES

Filed Nov. 13, 1950

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

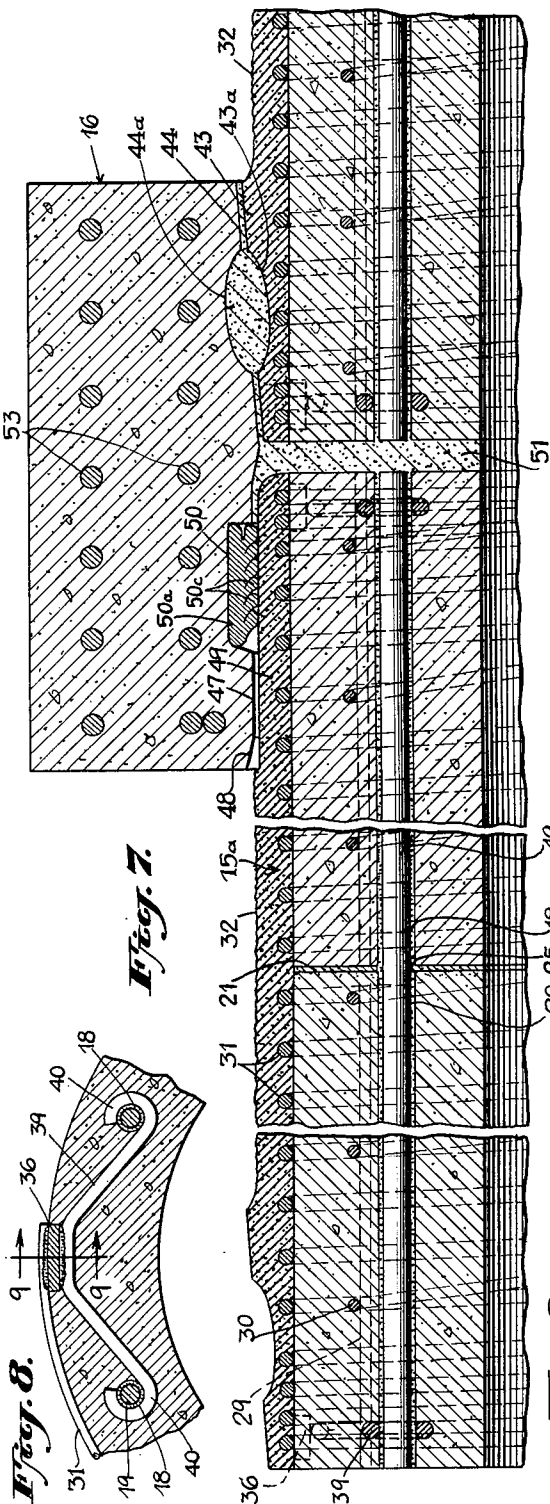


Fig. 7.

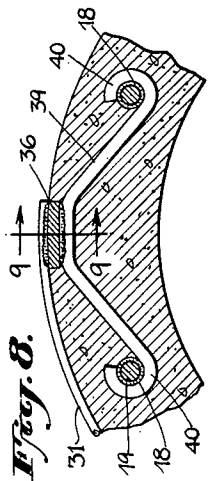


Fig. 8.

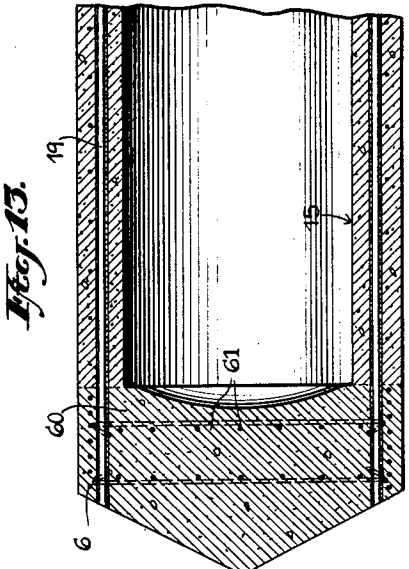


Fig. 13.

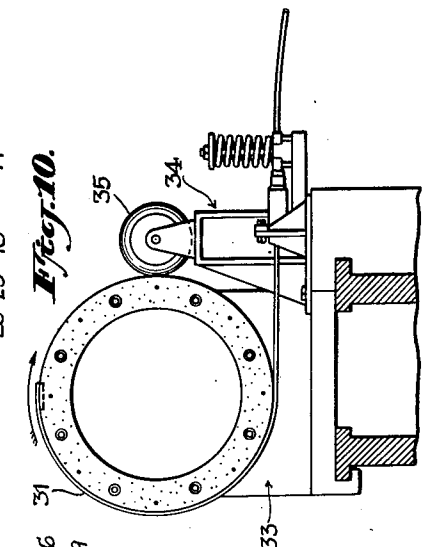


Fig. 10.

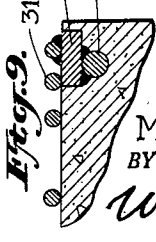


Fig. 9.

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3 Sheets-Sheet 3

Fig. 11.

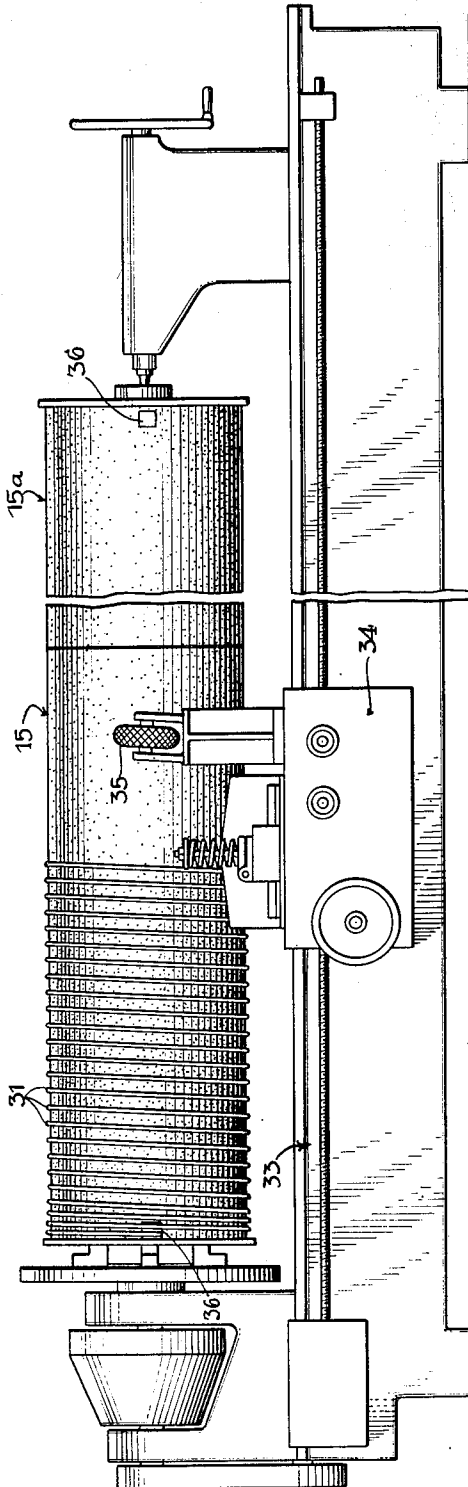
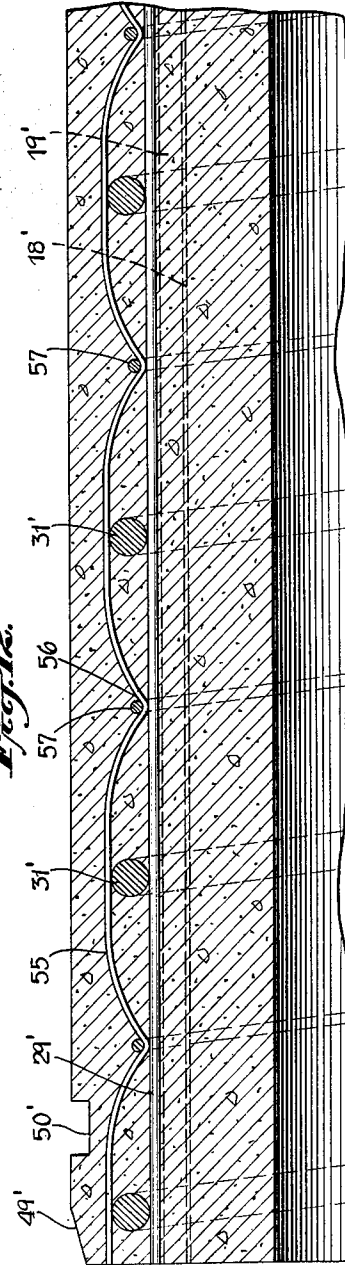


Fig. 12.



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Application November 13, 1950, Serial No. 195,323

3 Claims. (Cl. 138—84)

This invention relates to prestressed tubular concrete structures particularly adapted, among other possibilities, for use as pipes or conduits, certain features of the invention also being well adapted for other uses such as concrete piles and caissons.

This application comprises a continuation-in-part of applicant's co-pending application Serial No. 114,790, filed September 9, 1949, and now abandoned, which in turn was a co-pending continuation-in-part of applicant's application Serial No. 781,259, filed October 22, 1947, and now abandoned.

The present invention contemplates casting the concrete in the form of tubular sections of suitable length, which sections in some cases may be used individually, although in most cases groups of these sections are assembled in end-to-end relation to form a conduit for example, preferably with a suitable simple sealing means interposed therebetween.

In accordance with the invention, the walls of each section have formed therein a plurality of longitudinal cavities or holes at circumferentially spaced positions extending within the concrete from end to end of the section, each such cavity communicating with a corresponding cavity through the next adjacent section or sections in case a group of sections is used. The sections are maintained prestressed longitudinally by highly tensioned wires which may extend through the communicating cavities of succeeding sections of such a group, such wires being held under tension by a filling of grout introduced into and along the cavities under pressure and acting securely and permanently to bond the successive portions of each wire to the adjacent successive portions of the concrete. The wires are threaded through the holes after the usual ageing of the concrete and tensioned by forces applied to the protruding ends thereof and which forces subject the concrete to longitudinal compression. After the grout has set, such forces are removed from the wire ends (which may then preferably be cut off flush with the concrete) and the grout as bonded to the wires and to the concrete of the walls of the cavities, is thereafter relied on for permanently securing the wires throughout the holes under high tension and at the same time holding the concrete under longitudinal compression. Thus the use of any permanent wire securing means which would interfere with the joints or couplings at the ends of the sections, is avoided. If the wires extend through a group of sections, they will thus also hold the sections end-to-end under pressure, with the sealing means therebetween also tightly held under pressure.

If the structure is to be used as a high pressure fluid conduit, for example, it will also be necessary to provide means for reinforcing or prestressing the same circumferentially. For this purpose, after a section or group of sections has been prestressed longitudinally as above indicated, preferably helical windings of wire or a series of closely spaced wire loops under heavy tension are applied around on the exterior surface of the section or assembled group of sections, the ends of the wire being suitably affixed to the concrete.

Such method of prestressing circumferentially after prestressing longitudinally in the manner above described, has a number of important advantages. Individual sections or groups of such sections end-to-end, after being prestressed longitudinally in this way, will in effect provide a beam of unusually great strength considering the quantity of concrete used. Hence the

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structure will have sufficient strength to permit application of the circumferentially wound prestressing wire under great tension without danger of distortion or breakage of the concrete which preferably is supported and rotated for example in a lathe-like apparatus during the winding on of the helical wire. The invention also has the advantage that several end-to-end sections may be prestressed longitudinally concurrently in one operation (which also tightly seals the abutting end joints) and then also prestressed circumferentially in one operation as an assembled unit. This affords substantial economy in that it makes necessary for each of the operations only one set-up of the apparatus for a group of sections. Also, the conjoint effect of such longitudinal and circumferential prestressing has the advantage that, at the regions of the abutting ends of the sections of each group, all parts of the concrete and whatever sealing means is used between the abutting ends are in effect held and clamped against cracking in any direction. Furthermore, the initial longitudinal prestressing tends substantially to limit the degree to which the concrete may be compressed circumferentially (because of the Poisson effect) and hence, when the circumferential prestressing wire is wound on under tension, greater assurance is afforded against any deformation of the pipe or reduction of the wire tension during the winding, or gradually at later times upon further ageing of the concrete. To effectively maintain a high degree of prestressing in concrete, it will be understood that it is necessary that the tensioned wires are not only put in place under high tension, but that they also maintain the greater part of the initial high tension permanently. With the present invention the two types of prestressing mutually contribute to this result.

If an attempt is made to form the concrete sections with sufficient longitudinal reinforcement of the ordinary non-prestressed type, the amount of steel required to give adequate strength would be quite substantial and such steel would be so effective in resisting compression of the concrete as to work against any subsequent steps taken to properly and effectively prestress the structure. Thus the present invention by avoiding any substantial amount of reinforcement installed by casting same in place in non-prestressed condition, makes possible both longitudinal and circumferential prestressing to a high degree.

Heretofore, so far as I am aware, with concrete pipe and the like made in sections, it has been necessary to provide a relatively expensive joint means or coupling between all sections to insure a fluid-tight durable construction and to provide for expansion and contraction, and where any effective form of so-called prestressing was desired, it was necessary to prestress the pipe sections individually and independently by the use of relatively expensive methods. On the other hand, with the present invention, pluralities of the sections as assembled end-to-end may be prestressed readily in groups at or near the place of installation, and in a way such that the possibility of leakage between sections of each group is avoided without any substantial expense for joints between the sections of each group, and expansion and contraction are provided for by an improved form of joint which is used only between groups of sections.

While with the preferred embodiments of the invention the circumferential prestressing wire is wound on after the longitudinal prestressing, yet according to another form of the invention some degree of circumferential reinforcement and prestressing may be obtained by providing in the concrete walls of each section as cast, a helix of heavy wire in a position to surround and embrace at least that portion of the concrete of the section walls which is to contain the longitudinally tensioned wires. With such construction, the effect of the longitudinal compression in conjunction with the confining effect of the helix of wire, acts to maintain the inside wall portions of the concrete under compression circumferentially. That is, the concrete as held under longitudinal compression, is confined against expansion radially outward by reason of being surrounded by the helix of wire in the concrete, and at the same time the concrete is restrained from expanding in directions radially inward of the sec-

tion by reason of the arch effect of the interior walls. Consequently the concrete as thus confined is caused to be placed under compression circumferentially, or in other words is to some extent prestressed circumferentially as well as longitudinally. However, in the case of conduit structures designed for high pressures, adequate and economical circumferential prestressing is preferably accomplished by the winding on of high tensioned wire after longitudinal prestressing.

Further and more specific objects, features and advantages of the invention hereof will appear from the detailed description given below, taken in connection with the accompanying drawings which form a part of this specification and illustrate by way of example, preferred embodiments of the invention.

In the drawings:

Fig. 1 is a longitudinal sectional view of a pipe or conduit embodying the invention in its preferred form;

Fig. 2 is a view showing in separated relation a plurality of the pipe sections which are to be secured together to form a group of sections;

Fig. 3 is a view similar to Fig. 2, but showing the same parts as secured together to form a group of sections, portions of other sections forming parts of other groups being indicated in dotted lines;

Figs. 4, 5 and 6 respectively are transverse sectional views taken substantially along lines 4-4, 5-5 and 6-6 of Fig. 1;

Fig. 7 is an enlarged longitudinal sectional view taken substantially along line 7-7 of Fig. 4;

Figs. 8 and 9 respectively are transverse and longitudinal sectional views partly broken away, indicating one suitable type of means for securing the ends of the externally wound helix of prestressing wire in place;

Fig. 10 is a sectional view of the pipe as of Fig. 1, accompanied by apparatus for winding thereon the circumferential prestressing wire;

Fig. 11 is a side view of the apparatus of Fig. 10 as arranged to wind the circumferential prestressing wire onto an assembled group of longitudinally prestressed tubular sections;

Fig. 12 is a sectional view similar to Fig. 7, but showing an alternative embodiment of the invention; and

Fig. 13 is a sectional view of one of the tubular sections with a pile point located thereon and prestressed in conjunction therewith.

Referring to the construction of Fig. 1 in further detail, three of the above-mentioned end-to-end tubular concrete sections are indicated at 15, 15a and 15b, sections 15, 15a (as indicated in Figs. 2 and 3) forming a part of one group of sections and 15b forming one of another group of sections connected to the first group by the novel form of reinforced concrete joint means indicated generally at 16.

As shown in Figs. 1 and 4 and more clearly in Fig. 7, the walls of each of the sections have formed therein a plurality of longitudinal cavities at 18 at circumferentially spaced positions extending within the concrete from end to end of the section, such cavities of one section communicating directly with like cavities of adjacent sections of the same group. Each of these cavities contains a longitudinally extending wire or a group of wires 19, such wires extending from end to end of a group of sections, and as hereinafter further explained, these wires are installed and maintained under heavy tension, for example in the neighborhood of 125,000 to 150,000 lbs. per square inch (assuming that the ultimate strength of the wires approximates 200,000 lbs. per square inch, for example). With the preferred forms of the invention, this tension is maintained by filling the cavities 18 about the wires with a high grade of cement grout as at 20 (Fig. 7) introduced along the cavities under pressure while the wires are being held under heavy tension as by the use of hydraulic jacks mounted to exert pressure against the end of a group of concrete sections while pulling on one end of each wire, the opposite wire end at the other end of the group of sections being anchored by any suitable means. Thus while the grout is being introduced and allowed to harden, the concrete of all of the sections of the group is maintained under substantial longitudinal compression by forces equal and opposite to those which concurrently retain the wires under tension. After the grout has been allowed to set and harden, the means for tensioning the wires may be removed and the wire ends respectively cut

off substantially flush with the end surfaces of the group of sections (see Fig. 7).

The expressions "heavy tension" and "highly tensioned" as used in the appended claims, have reference to tensions such as above indicated and which are sufficient to permanently maintain the concrete under compression in effectively prestressed condition, despite the plastic flow effect or "creeping" of the concrete or of the somewhat similar effect which takes place in the steel, such prestressing for these reasons not being possible with the ordinary reinforcing bars or rods which do not have the strength to withstand sufficiently heavy tension for such purpose.

It will then be found that the successive portions of all of the wires along their lengths respectively are firmly and permanently bonded to the adjacent successive portions of the concrete within the cavities 18, thereby in effect permanently affixing each such portion of concrete under compression with respect to adjacent wire portions under tension. Thereby the effect of great tensile strength is permanently imparted to the concrete in longitudinal directions all along the wires, and this prestressing effect is permanently distributed and maintained throughout the length of each group of tubular sections, rather than being necessarily dependent upon conditions at the ends of each section or at the ends of each group of sections. Also if defects ever occur in portions of some of the wires or in the bonding of the wires at certain points, the prestressing of the concrete at other regions continues to be effectively maintained. Since careful tests have shown that with this way of bonding the wires in place, permanent locking means to hold the ends of the wires against slipping are not necessary or essential, the wires may be cut off flush with the ends of the group of sections whereby the wires will not interfere with the joint means (as at 16) used between groups of sections.

The longitudinal compression attained as above described has the effect of pulling the ends of successive sections of each group so tightly together that the pipe is readily made fluid-tight simply by using a suitable cement, or plastic paste at 21, or a simple gasket of corrugated metal or other recognized joint packing may be used between sections. If the end surfaces of the sections are formed to closely fit, it will be found that a tight permanent seal may be secured in this way, since the ends will be held under great pressure by reason of the tensioned wires 19. This function of the tensioned wires makes possible an important saving in the cost of the conduits, through avoidance of the necessity of using any complicated or expensive coupling and joint means between the sections of each group. As shown in Figs. 5 and 7, the tensioned wires 19 pass through apertures as at 25 in the sealing means with enough clearance to permit the grout as introduced under pressure surrounding the wires readily to pass along the wire cavities throughout the group of sections and such grout contributes along with the sealing means 21 to sealing and protecting the wires against moisture and corrosion at the points where they pass from one section to the next. The sealing means (under the heavy pressure of the tensioned wires at the joints) prevents and insures against any leakage or loss of pressure of the grout until same has set, thus insuring the necessary firm grout bond.

U. S. patent to Parry No. 2,609,586, granted September 9, 1952, discloses convenient methods and means for tensioning the wires and introducing the grout-bonding material under pressure.

In cases where the sections are to be used individually, they may of course be longitudinally prestressed individually in the above-described manner, except that the wires 19 extend only through one section while being tensioned, rather than through a group.

To insure against breakage of the sections during handling, a number of lightweight longitudinal reinforcing wires may be cast therein as at 29 at circumferentially spaced positions around within the walls and also a helix of relatively small wire as at 30 (Fig. 7) may be cast in place. Except for such lightweight and inexpensive reinforcements desirable for handling of the sections before prestressing, it is unnecessary to provide any non-prestressed reinforcement and accordingly the expense of such reinforcement in heavy form or in the form of steel cylinders as heretofore often required, is avoided with this invention. Such reinforcements as at 29 and 30 as cast in place should not be of such strength as materially to interfere with either the action of the longitudinal pre-

stressing wires 19 above described, or the circumferential prestressing wire hereinafter described.

During casting of the concrete sections, the longitudinal cavities 18 may be formed by providing in the mold, mandrels formed of or covered by resilient material such as rubber, these mandrels being readily removable, because of such resilience, after the concrete has set. Improved methods and apparatus for forming the concrete sections with these longitudinal cavities by the use of rotatable molding apparatus are disclosed in co-pending applications of John T. Parrett, Serial No. 129,657, filed November 26, 1949 (now Patent No. 2,550,858, granted May 1, 1951) and Myers Van Buren, Serial No. 131,816, filed December 8, 1949, now Patent No. 2,602,979, granted July 15, 1952. However, since with this invention no prestressing is to be accomplished during the casting of the sections, they may be cast in other suitable known ways, provided the ends are accurately formed or ground.

After the sections have been cast and allowed to age for a number of days and then longitudinally prestressed as above described, they are preferably circumferentially prestressed by winding thereon a helix of high tensile strength wire as at 31 under tension of the same magnitude as above specified for the longitudinal prestressing wires. This may be accomplished by rotatably mounting a tubular concrete section or a longitudinal prestressed group of the sections in a large lathe or lathe-like apparatus such as generally indicated at 33 in Figs. 10 and 11. Apparatus of a suitable known type such as indicated at 34 is provided gradually to move along the lathe carriage as the concrete structure rotates and to pay out the wire 31 under heavy tension to form a helix tightly embracing the outside walls of the tubular concrete structure in a manner which will readily be apparent from Figs. 10 and 11. In the case of large concrete structures and the use of very heavily tensioned wires, the device 34 should also carry a rotatable follower or rest wheel as at 35 bearing against the concrete near the area where the wire is being applied to provide reaction against the pull of the wire. The position of this wheel and the consequent reaction against the concrete may be adjustable if desired.

The ends of the helix of the wire may be affixed with respect to the concrete in various ways, one of which is indicated in Figs. 8 and 9. Here a plate member 36 is provided to which the end portion of the wire 31 is welded. Plate 36 may be welded on its under side to a rod as at 39 cast in place in the concrete, such rod preferably having its ends as at 40 respectively curled around the regions where two of the cavities 18 are located and which contain the longitudinal prestressing wires 19. As indicated in the drawings, the last two or three turns of the helix of wire may be more closely spaced, and in winding the same in position, when the last turn is reached, the winding tension may be reduced by, say, one-half so that the end as welded in place will not be subjected to excessive strain. Despite the reduction of the tension in the end turn, friction against the concrete will serve to maintain the other turns under the desired full tension.

Since the concrete sections or groups thereof have been very effectively prestressed longitudinally before they are placed in the lathe or lathe-like apparatus 33, they will have the rigidity of strong beams, and thus be well able to withstand the powerful forces to which they are subjected during the winding on of the wire 31, without deformation or breakage. It should be further noted that the prestressing of concrete generally cannot be carried out to the degree that would otherwise be possible because of the plastic flow effect or "creeping" of the concrete, as well as a somewhat similar effect which takes place in the steel, with the result that after the prestressed structure stands for a short period, the prestressing originally applied is reduced by a substantial percentage. On the other hand, with the two-stage prestressing method herein described, viz. longitudinal prestressing followed by circumferential prestressing, at least some part of the amount by which the initial longitudinal prestressing is reduced by creeping effects may be later restored when the circumferential prestressing is applied, since the embracing of the concrete circumferentially will, because of the Poisson effect, tend to expand the concrete longitudinally against the resistance of the longitudinal prestressing wires. The degree to which this effect may take place will of course depend upon the

relative forces applied, the dimensions of the concrete and of the prestressing wires.

After the helix of wire 31 is fixed in place, same may be covered and protected by a coating 32 comprising a layer of cement, plaster or any of various available tar-like compositions.

In order to provide a joint between each succeeding group of sections, one end of an end section of a group is accurately cast or ground to tapered form, as indicated at 43 at the right hand end of Fig. 7. This end is adapted to fit into a correspondingly tapered interior opening 44 of a pre-cast sleeve 16 (see mid-portion of Fig. 1) the opening of which is also accurately cast or ground to fit the tapered end 43. This sleeve is pressed onto the tapered end of the pipe section, the tapered surfaces being suitably grouted, and also preferably formed with complementary grooves respectively, of semi-elliptical cross-section at 43a and 44a. These grooves provide an annular cavity of elliptical cross-section, which, after the sleeve is put in place, is filled with grout through a radial opening 46 (Fig. 6), and upon the hardening of such grout, it will be apparent that the sleeve will be firmly locked in place and sealed on the end of the pipe section. As shown in Fig. 6, a radial air outlet opening 46a may also be provided near the opening 46, so that as the grout is injected into the latter, it will readily proceed along the annular cavity, and when the same is filled, the excess will appear at opening 46a. The annular cavity may be interrupted at 46b at the region between the inner ends of the openings 46, 46a, so as to insure that the grout will follow the desired circuitous path and completely fill the same.

The other end of the sleeve 16 (Fig. 7) is formed with an opening 47 having its outer portion at least at 48 also somewhat tapered or suitably shaped to readily receive and firmly retain the end portion 49 of a section such as 15a. Within the walls of the opening 47 an annular groove 50 is formed containing a rubber gasket 50a which closely embraces the external surface of the pipe section 15a. Preferably this gasket is formed on its inner surface with a series of overlying annular leaves 50c directed inwardly and toward the end of pipe section 15a. If and when the fluid pressure in the conduit reaches the portions 50c, they are so shaped and positioned that they will be crowded forcibly in overlapping relation against the surface of the pipe section, thus insuring sealing of the joint at this region, while still permitting the gasket to slide along the pipe section upon expansion or contraction of the conduit. After the two pipe sections have been put in place within the sleeve 16 (as shown in Fig. 1) and pressed together, the joint or space between the ends thereof at 51 may also be filled with grout or other sealing means applied from the inside of the pipe to provide additional protection against the escape of fluid.

The sleeve 16 is preferably reinforced by forming the same with helical wires as at 53 embedded therein. This form of joint or sleeve means, which includes a comparatively small amount of steel, may be manufactured economically as compared with joint constructions heretofore generally considered necessary for concrete pipe, and embodying relatively more expensive closely fitting steel parts which have to be welded or otherwise secured, generally to steel cylinders or other reinforcing means extending throughout the pipe. At the same time, the joints as here shown, while permanently, rigidly and tightly locked to the end of one pipe section, engages the adjacent pipe section in a manner such as to permit limited longitudinal travel to occur without leakage, thus meeting the problem of expansion and contraction which is involved with most long pipe lines, but without resorting to the expense of providing such a coupling means between every adjacent pair of sections. The number of couplings used, or in other words the number of pipe sections comprised in each group, may be varied according to conditions prevailing on each job. Under most other circumstances, at least one-half to three-quarters of the expense of joints may be eliminated by prestressing the sections in groups of from two to four.

Large conduits with relatively thin concrete walls may be made in the manner above described, which will withstand heavy fluid pressures without cracking. But even if they are subjected to such abnormally heavy pressures, during testing for example, as to cause excessive stretching of the tensioned wires permitting the concrete to

crack with consequent leakage, yet when the fluid pressure is reduced to the normal amount for which the conduit is designed, the tensioned wires will again firmly close and tightly seal the cracks against further leakage.

With the alternative embodiment of the invention as shown in Fig. 12, longitudinal cavities 18' and longitudinal prestressing wires 19' may be provided as in the case of Fig. 7. Also, small longitudinal wires as at 29' may be provided for longitudinally reinforcing the concrete during handling prior to prestressing for purposes comparable to those of wires 29 above described in connection with Fig. 7. However, with the form of the invention shown in Fig. 12, the circumferential prestressing wire or helix 31' may be installed and subjected to tension in either of two alternative ways, viz. the whole mass of the concrete wall, a section of which is shown in Fig. 12, may be cast integrally with the helix 31' embedded therein, or the inner portions only of the concrete wall may be first cast, then the wire 31' may be wound thereon under heavy tension in a manner similar to the way in which wire 31 is wound in place as above described in connection with Fig. 1; thereafter the outer portion of the concrete walls, as shown in Fig. 12, may be cast upon the wire helix 31'. In case the whole wall, as shown in Fig. 12, is cast about the helix 31' (while the latter is not tensioned) then upon longitudinally prestressing the concrete sections (or groups thereof) by the wires 19', there will occur a certain degree of tensioning of the helix 31'. That is, the concrete as placed under longitudinal compression is confined against expansion radially outward by reason of being surrounded by the helix 31' and at the same time the concrete is kept from expanding radially inward by reason of the arch effect of the interior walls. Consequently the concrete as thus confined is caused to be placed under some compression in circumferential directions, the helix 31' being at the same time placed under circumferential tension depending upon the extent to which the Poisson effect takes place. On the other hand, if this structure is made by first casting the inner portions only of the concrete wall and then winding same with the wire 31' and covering the latter with further concrete, then the wire 31' may be initially wound in place under substantial tension, thus circumferentially prestressing the inner wall portions of the concrete before they are prestressed longitudinally by the wires 19', instead of afterwards as above described in connection with Fig. 7.

With the form shown in Fig. 12, while the inner wall portions of the concrete as prestressed and ready for use are subject to compression, the outer portions of the concrete tend to become subject to tension, particularly when the pipe or conduit is filled with fluid under pressure. Hence in order to prevent the inner and outer portions of the concrete from tending to crack apart due to such opposed strains, an additional reinforcing means is preferably provided in the form for example of a lightweight open mesh wire means as at 55 largely located in the outer wall portions, but also having a helically indented portion as at 56 extending into that portion of the concrete which is under compression. If desired, this indented portion may be embraced and held in place against the reinforcements 29' by a small helically extending wire as at 57.

When the invention is to be used for construction of hollow concrete piles, for example, instead of pipes or conduits, a plurality of the end-to-end concrete sections may be made and prestressed longitudinally and circumferentially in accordance with any of the methods above described, although for this purpose, circumferential prestressing to a substantial degree will usually be of less importance.

As indicated in Fig. 13, the lower one of the tubular sections 15 which is to be located at the bottom end of a pile, may be accompanied by a pile point or cap member 60 having cavities through which longitudinal prestressing wires 19 are pressure grouted in place under tension in the same way as such wires are secured in the tubular sections. The point member 60 may be cast with suitable reinforcing as at 61 therein, including, if desired, a helical reinforcing wire 62 extending around within the peripheral portions of the concrete.

Although certain particular embodiments of the invention are herein disclosed for purposes of explanation, various further modifications thereof, after study of this specification, will be apparent to those skilled in the art to which the invention pertains. Reference should accordingly be had to the appended claims in determining the scope of the invention.

What is claimed and desired to be secured by Letters Patent is:

1. In the forming of tubular prestressed concrete structures by the use of tensioned wires and a plurality of tubular concrete section members having a plurality of longitudinal holes located within and surrounded by the concrete at circumferentially spaced positions around within the walls of each section, the method which comprises placing said sections as a series in end-to-end relationship with sealing means between the ends and with such holes in each section aligned and communicating with corresponding holes in the adjacent section, threading a group of wires through each of said holes and stressing said wires under heavy tension by forces applied to the ends thereof, and subjecting the series of sections to longitudinal compression, bonding the successive portions of the wires to each other and directly to the adjacent portions of the concrete in the holes by injecting a filling of grout under pressure into and along the holes, and removing said stressing forces after said grout has set, the grout bond thereafter being relied on for permanently holding the wires substantially throughout the holes under tension and the concrete sections under permanent end-to-end compression with the sealing between the section ends also held tightly under compression.

2. The method which comprises the combination of steps as specified in claim 1 and including the step of thereafter winding and securing turns of wire under heavy tension around on the exterior surface of the assembly of sections at spaced positions substantially from end to end thereof to retain same, including the abutting end portions of the section members, permanently under substantial circumferential compression.

3. A prestressed tubular concrete structure adapted for use as a pile, comprising a plurality of tubular concrete sections positioned end-to-end axially in alignment with sealing means between the ends, each section having a plurality of longitudinal holes located within and surrounded by the concrete at circumferentially spaced positions around within the walls of the section, each such hole communicating with a corresponding hole through the next adjacent section or sections, a group of highly tensioned wires extending through the communicating holes of succeeding sections, a filling of grout in said holes acting permanently to bond the successive portions of said wires to each other and to the concrete surfaces in the holes, the tensioned wires acting through such grout bond to subject the concrete of each section permanently to heavy compression longitudinally and to maintain the sections together under end-to-end pressure with the sealing means between the ends permanently held under compression.

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