



The present invention relates to a process for obtaining a conduit having the form of a cylinder resting on the ground by means of a base having a general transverse curvature lower than the rest of the wall of the conduit. Reference is made to the European Divisional
5 Application 244,890 published on the 11th November 1987.

Such structures are typically conduits of large cross-section, for example beyond the traditional industrial products of the order of 2 m^2 , buried or not, serving
10 for the supply of water or other fluid under pressure or without pressure or as passages for cables and/or other conduits or for the movement and standing of people or vehicles.

The invention can also be used for conduits of smaller cross-section, for example up to 1 m^2 . It can also
15 be employed to obtain structures of similar, but relatively short form that can be used as cellars, silos or nuclear shelters or the like.

Although the invention is described essentially by reference to conduits of large cross-section, it is
20 therefore not limited to this technical sector.

Various techniques are employed for the installation of conduits intended for water supply, oil transport, passages of cables or other conduits, etc.

The most common technique involves using tubular
25 portions of circular cross-section which are placed end to end and joined together by various methods. This technique has disadvantages which increase with the diameter of the conduit, even if the length of the portions is reduced: production, transport, handling and installation. At all
30 events, in addition to the production problems, problems of bulk arise in the neighbourhood of an outside diameter of 2.50 m which corresponds to the normal limit of road allowances. For high flow volumes, it is necessary to provide several conduits in parallel, this being a costly
35 solution, or to construct the conduit on the spot by the techniques of brickwork buildings or even of gallery work which are likewise costly and involve long periods of production or execution.



In a known process described, for example, in the documents FR-A-2,030,937 and DE-A-2,157,191, the conduit consists of portions placed end to end and produced by assembling longitudinal elements prepared in advance, each
5 corresponding to part of the cross-section of the wall and bearing on one another along longitudinal joints. The elements are made of corrugated sheet metal and are therefore easy to transport and assemble simply by bolting or riveting.

10 On the other hand, as is known, the circular form of the conduits is the most suitable for high internal pressures. Moreover, it is the easiest to obtain when portions corresponding to the entire cross-section of the conduit are produced. In contrast, it has disadvantages in
15 other uses. A circular conduit generates, in the ground supporting its weight, stresses which are at a pronounced maximum in its middle region. As a result of this, if the ground lacks firmness, considerable differential subsidence can occur after installation. The circular form is
20 unsuitable for a utilization of space when this is crowded, as often happens in an urban environment. Finally, the weight of the conduit is relatively too high; in fact, as regards unit portions each covering the entire cross-section, the material is distributed uniformly
25 over the entire periphery, whereas the stresses are not.

Documents FR-A-2,030,937 and DE-A-2,157,191, provide in some cases for producing conduits of flattened cross-section, each portion comprising, in cross-section, a lower part forming a base with a flat bottom resting on
30 the ground and joined at the sides to a curved upper part forming an arch. However, where large cross-sections are concerned, it is difficult to image that the conduit will consist solely of metal walls buried directly, because, even if they are made of corrugated sheet metal,
35 such elements have only a low resistance to external stresses, thus making it doubtful whether the form of the cross-section and the sealing of the joints will be conserved. Consequently, the metal walls limiting the



conduit are normally only expendable formwork requiring subsequent concreting. Furthermore, the corrugations increase the resistance of the conduit to the circulation of fluids.

French Patent 733,098 or US Patent 2,400,071 also
5 make known techniques involving assembling a large number of elements of small dimensions, each equipped with transverse rims serving for joining to the adjacent elements. Because of the large number of elements, they have to be given an identical form, thus making necessary to adopt a
10 cross-section of circular form, and in this case the stress resistance requires the junctions to alternate in the longitudinal direction. Although US Patent 2,400,971 provides for taking into account some of the stresses exerted on the wall and using elements of lower resistance for the upper
15 part of the cross-section of a tunnel than for the lower part, nevertheless, on the one hand, a method of assembly of elements of different characteristics by means of alternating joints affords doubtful stability and, on the other hand, it introduces an additional complication in the
20 installation by the assembly of a large number of small elements, whilst such installation is difficult for unqualified personnel to carry out perfectly.

Thus, it seems that there is an unsatisfied need for a process which makes it possible to obtain cylindrical
25 cal hollow structures resting on the ground along a generatrix and having a cross-section of a form flattened at the base, especially conduits of large cross-section or similar structures, this process making it possible to arrive at structures of high mechanical resistance for production,
30 transport and installation cost prices which are considerably reduced in comparison with the current techniques.

The present invention therefore provides a process for obtaining a conduit corresponding to the characteristics of Claim 1. This conduit is limited by a cylindrical
35 wall, not of revolution, resting on the ground by means of a base having a general transverse curvature lower than the rest of the wall, by the assembly, on the spot, of longitudinal elements prepared in advance, each

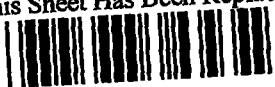


corresponding to part of the cross-section of the wall of the conduit and bearing on one another along longitudinal joints, each portion consisting, in cross-section, of at least two elements, namely a lower element forming a base
5 with a flat bottom and two sides for connection to a curved upper element forming an arch.

According to the invention, a prior calculation of the stresses of the structure as a whole is made, taking into account all the known parameters relating to the
10 installation site, the conditions of use and the inherent characteristics of the conduit; according to the result of this calculation, the form of the longitudinal elements is determined so that at least some of the longitudinal joints between adjacent elements are in the vicinity of the "stress
15 nodes", that is to say points where the absolute value of the stresses transverse relative to the wall passes through a minimum, then a calculation of the stresses is carried out element by element, and according to the result of this calculation the exact form of the curvature, the thickness
20 of the cross-section and the material of each element are determined.

In normal circumstances, the joints of structures according to the invention are not in an alternating arrangement. On the contrary, the longitudinal joints are in
25 the extension of one another on either side of each transverse joint.

The process according to the invention has a first advantage in relation to the current technique, namely that transport is made easier. In fact, if it is assumed that
30 the maximum permissible dimension is 2.5 m, the current technique allows only the unit transport of portions of an outside diameter at most equal to 2.5 m. If the elements according to the invention each correspond to a quarter of the cross-section of the conduit, the latter, once completed,
35 can have a diameter of approximately 3.5 m, that is to say a cross-section of double the area, and if the elements correspond to a sixth of the cross-section, once completed, it can have a diameter of approximately 4.4 m,



that is to say three times the cross-sectional area. Moreover, for the same height of 2.5 m, a considerable number of unit elements, stacked on one another, can be arranged in the same volume, with the result that the same transport vehicle will be used at its maximum carrying capacity. In contrast, the total length of the junctions to be made by welding or any other means is obviously increased. It must be noted that the joints are normally straight joints which are much easier to obtain or make than circular joints, and that, on the contrary, the number of these can be reduced because of the greater unit length of the elements which is allowed by their lower unit weight.

Another advantage of the invention arises as a result of the non-circular form of the structure, the disadvantages of a circular form being mentioned above.

Furthermore, because of the cross-section of a form flattened at the base, there is a considerable improvement in the distribution of the stresses generated in the underlying ground, and the movements of this can be reduced considerably. Another advantage of such forms is a smaller height for an equal cross-section, thus affording a reduction in the excavation costs (earth works, shoring, lowering of the groundwater level, etc.). On the other hand, if the consistency of the supporting ground so requires (the water table in particular), it is possible to incorporate in the conduit a ballast obtained by means of masses of metal or concrete which are secured under the raft of the said conduit by suitable bolting. Of course, the mass of the ballast is calculated according to the data particular to the site in question, and each of the ballast elements can also be prefabricated. The conduit can also be anchored to the ground by means of this same bolting process which is made easier from the inside as a result of the flattened form of the raft.

On the other hand, the prior calculation of the stresses to which the elements of the conduit will be subjected and the use of the result of this calculation to determine the thickness of each element, the variation of



the thickness from one point of the cross-section to another, the material of which each element is made and the location of the longitudinal joints afford considerable advantages:

5 In fact, the upper part of a conduit often performs a purely protective function and is subjected only to limited stresses. On the other hand, the weight of the transported fluid, when it is water or another free-flowing liquid, obviously acts more in the lower part than
10 at the top. Moreover, the sealing obtained at the assembly joints allows the conduit to withstand internal pressures and therefore be used as a forced conduit. It will also be seen that, since the conduit in its final form is a homogeneous and integral unit, there will be no need to
15 provide abutments at the changes of direction, these generating longitudinal thrusts. The possibility of adjusting the thickness and material of the element allows large savings to be made on the cost price and on transport.

20 As mentioned above, the various elements can be of different thicknesses, depending on the result of the stress calculation. They can also be produced with different materials, provided, however, that, if need be, the necessary precautions have been taken to prevent corrosion
25 as a result of the electrochemical contact effect.

 Of the preferred materials, ductile cast irons may be mentioned because of their low price and the ease with which they are obtained and assembled by welding and/or other means, but other materials can be considered alone
30 or in combination, such as steel, aluminium alloys, other metals, plastics reinforced or not with fibres, concrete, reinforced or not, prestressed or not. In the last two cases, it is obvious that the welds mentioned above must be replaced by suitable connections.

35 If the conduit elements are produced by integral casting or by continuous cross-sectional shaping, particularly by extrusion, of materials, such as ductile cast iron, steel, reinforced concrete, resins, etc., the mould



or die used is advantageously of a cross-section which is shaped so as to reproduce, as a result of the action on the inner surface of the conduit element, the abovementioned variations of ideal profile and also the transverse variation in the thickness.

The changes of direction are obtained by means of curved canted prefabricated elements specially calculated and adapted to the said geometry.

The construction of a conduit according to the invention, that is to say by means of elements which correspond only to part of the cross-section, but which, by compensation, can be of considerable length, presents specific problems at the time of assembly; it has been possible to solve these problems by the following assembly process which is therefore associated closely with the main subject of the invention. According to this process, the initial assembly of the elements is carried out by connecting them to one another both longitudinally and transversely by means allowing a limited relative movement of the adjacent elements and by inserting a sealing joint made of flexible material between them, and subsequently the elements are assembled together permanently and rigidly when the surrounding soil and the conduit as a whole have stabilized. The initial assembling together of the elements is preferably carried out by means of bolts passing through at least one of the elements via a hole widened accordingly.

However, other joining methods can prove more advantageous, particularly in joints where the high stresses necessitate large wall thicknesses. In these cases, it is preferable to adopt one or more of the following procedures:

- to carry out the longitudinal junction and, if appropriate, the transverse junction of the conduit elements, recessed or projecting parts are formed, and these are located in the zones of the corresponding edges and can interact by a matching of forms and/or forces in order to produce the necessary longitudinal and transverse joints;
- to produce longitudinal joints, a rib is formed



on each of the edges of two elements to be joined and locking means are distributed over the length of the two ribs so formed;

- the locking means are rigid elastic stirrups or
- 5 - the stirrups are fastened by means of rigid or elastic pieces fitted between the inner surface of the stirrup and the flank of the corresponding rib or as a result of the elastic deformation of the stirrups themselves;

- 10 - gaskets of a cross-section shaped to correspond to the edges of the longitudinal and transverse joints are interposed between the said edges, and they are clamped sealingly from use of the said stirrups or by means of collars, straps, prestressing cables or other
- 15 means ;

- if the elements are formed from weldable or sealable materials, the longitudinal and transverse joints are made by the addition of corresponding welding or sealing material.

- 20 According to an expedient embodiment, to make the installation and stabilization of the conduit easier, there are placed stabilizing elements of triangular longitudinal cross-section on the sides of the lower face of the conduit. These elements have a horizontal plane face which is approxi-
- 25 mately level with the bottom of the conduit, and an approximately vertical or inclined plane face and a face which matches that of the conduit. These stabilizing elements are preferably discontinuous and are fitted from place to place along the conduit, to prevent the lower element from tilt-
- 30 ing on its longitudinal axis after it has been installed.

These stabilizing elements can be fastened to the structural element of the conduit by bolting, welding or the like. If this structural element is obtained by casting (concrete), they can also be integral with it.

- 35 In addition to their usefulness for stabilizing the entire conduit, the stabilizing elements are advantageous when the conduit is formed from elements of which some form the bottom and others lateral walls with a general



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vertical orientation: by ensuring that the stabilizing elements are fastened to the lateral-wall elements beforehand or are in one piece with these elements, the latter become capable of standing upright when they rest on the ground, thus making it easier to join them to the bottom elements laid first. Subsequently, the elements forming the top can be installed by placing them on the lateral-wall elements.

If the cross-section of the hollow structure is relatively small, for example a conduit of approximately 1 to 4 m², the cross-section of the conduit can be formed by only two elements, of which one corresponds to the lower part and sides of the conduit and the other forms a cover. These elements or at least some of them can be made of concrete or another cast material.

According to another method of obtaining practicable joints when the elements are made of concrete or another cast material, on the edges of the longitudinal elements there are brackets made of weldable or adhesively bondable material, to which are fastened, after installation and preferably after stabilization, flat pieces for sealing purposes, made of a material compatible with that of the brackets.

In some cases, especially when dangerous fluids are to be transported or stored or for the construction of nuclear shelters, it is expedient to obtain perfect sealing even in the event of ground movements or a nearby explosion, and if the elements are constructed from concrete or another material which could crack or lose its sealing in another way, there is advantageously a leak-proof inner covering or lining fixed or not to the elements of the structure.

In some cases, this covering can form an expendable formwork part for the elements of the structure. If the covering is made of sheet metal or another weldable or adhesively bondable metallic or non-metallic material, flat pieces of the abovementioned type can be welded or adhesively bonded to the joints of this covering, or the



covering parts can be welded or adhesively bonded directly to one another in the region of the joints.

If the structure, namely a conduit or shelter, is formed from elements made of concrete, this provides the crushing resistance, whereas an inner covering consisting of sheeting, metallic or not, or plastic, welded, adhesively bonded or applied by any coating, affords absolute sealing relative to radioactive contamination or infiltrations or the like, even if ground movements or movements caused by an explosion have deformed the structure.

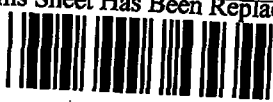
The following examples relate essentially to conduits of large cross-section, but it will easily be appreciated that what they describe applies equally to silos, shelters or similar structures.

Where a prefabricated nuclear shelter is concerned, longitudinal-wall elements, which can be formed in the same way as for conduits of large cross-section, are installed, and the shelter is closed at each end by means of plane or convex transverse walls. Preferably, the shelter is given a substantially flat bottom, and the base side elements are equipped with lateral-stabilization elements incorporated during production or added subsequently, in order to prevent the shelter from tilting about its longitudinal axis.

Advantageously, a leakproof inner covering is provided, especially if the shelter is constructed from concrete.

The shelter can be installed very quickly, because it is formed from separate elements which can easily be transported so as to be assembled on site. It can be placed in a trench, which is subsequently reclosed, or even, in some cases, can simply be placed on the ground. It will be seen that the form with the flattened base affords improved resistance to blast effects, in comparison with a brick-built shelter of cylindrical or parallelepipedic form.

The invention will now be described in more detail by means of non-limiting exemplary embodiments illustrated



by the drawings in which:

Figures 1 to 3 are diagrammatic cross-sections through conduits according to the invention.

Figure 4 is a partial cross-section illustrating a method of assembly.

Figure 5 is a diagrammatic perspective view of a conduit, the various portions of which are formed from longitudinal elements, the longitudinal and transverse assembly joints of which are indicated particularly .

Figure 6 shows an example of conduit elements having a gradual reduction of radial thickness towards the centre.

Figure 7 shows an example of conduit elements having a gradual increase of transverse thickness from left to right.

Figure 8 is a cross-section through a longitudinal joint showing a method of assembly with ribs and stirrups.

Figure 9 shows an example of a profile with the interlocking of the corresponding edge of two conduit elements to form a longitudinal or transverse joint.

Figure 10 shows another example of the profiling of the edges of elements in order to form a longitudinal or transverse joint.

Figure 11 shows yet another example of the profiling of the edges of elements in order to form a longitudinal or transverse joint.

Figure 12 shows an exemplary embodiment of an interlocking transverse joint, the sealing of which is obtained by means of an annular joint of special profile which is compressed by means of a suitable strap.

Figure 13 is a cross-section through the conduit of Figure 12, showing the strap of the sealing joint.

Figure 14 shows the formation of a joint with regard to elements consisting of reinforced concrete.

Figure 15 is a diagram illustrating results of stress calculations.

Figure 16 is a cross-section through a hollow structure portion of reinforced concrete, corresponding



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to the calculation of Figure 16.

Figure 17 shows another exemplary embodiment specially designed for conduits of small cross-section.

Figure 18 shows a method of obtaining the sealing
5 of the joint.

Figure 19 shows a method of clamping the joint.

Figure 20 shows another method of obtaining the sealing.

Figure 1 shows, by unbroken lines, the cross-
10 section of a conduit 1 obtained by means of the process of the invention and as a comparison, by broken lines, the cross-section through a circular conduit 2 of the same cross-section. The conduit according to the invention is obtained by assembling five elements of the same length.

15 Two base elements 3 are substantially plane; two side elements 4 have a variable curvature greater towards the bottom than towards the top; the profile is completed by an upper element 5 of a cross-section in the form of the arch of a circle. The example illustrated
20 corresponds, as an indication, to a cross-section of 10 m^2 . The total height H is 2.40 m and the width L is 5.00 m, as compared with the diameter D of the corresponding circular conduit which is 3.57 m. The trench necessary for the conduit according to the invention is wider at the base
25 than for the circular conduit, but is shallower; the total volume to be excavated can be less and the work easier to carry out.

Figure 2 shows another form of a conduit according to the invention, in which the elements of the bottom 3a
30 are curved slightly and which has two upper elements 5a instead of one.

Figure 3 shows yet another embodiment, the particular feature of which is that the bottom element 3b forms
35 a central gutter 6. The gutter is in the middle of the element 3b and is widened slightly, with the result that elements are identical and stackable for transport, but of course other arrangements are possible. According to the conventional technique, the addition of a gutter presents



a virtually insoluble problem.

Figure 4 illustrates an example of the mode of junction between two elements 4,5 arranged as elements 4a and 5a of Figure 2.

5 In a first phase, the element 4 is equipped with a connecting plate 7 fastened by means of a weld 8 which can be made at the factory or on the spot. This plate 7 has widened holes 9 which, during assembly, match up with widened holes 10 in the element 5. At the moment of as-
10 sembly, a flexible joint 11 made of elastomer or the like is inserted between the element 5 and the plate 7, and then the junction is made by means of a screw 12 and a nut 13.

When the set of elements corresponding to the following section of the conduit is assembled, slight
15 relative movements of the elements 4 and 5 can occur, for example under the effect of variations in level of the bottom of the trench. Slight movements can also arise as a result of the subsidence of the underlying soil. All these movements are made possible by the widening of the
20 holes 9 and 10. When these movements have ceased occurring, the final junction of the elements can be carried out by means of a weld 14. The screw 12 and the nut 13 can also be removed and the holes 9 and 10, or only one of the two, can be closed by welding.

25 Figure 5 shows a diagrammatic perspective view of a conduit obtained by carrying out the process according to the invention. This conduit comprises longitudinal elements, such as A1,B1,C1, etc. for the first portion, A'1,B'1, C'1, etc. for the second portion and so on and so
30 forth; these elements are connected to one another by means of longitudinal joints JL1, JL2, JL3, JL4, etc. and by means of transverse joints JT1, JT2, JT3, JT4, etc.

The process according to the invention, in a first step, involves determining the best possible cross-
35 sectional profile of the conduit in a known way by calculation as a function of the known parameters relating to the installation site, the inherent characteristics of the actual conduit and its conditions of use. The calculation



takes into account the forces subjecting the conduit to stress, especially:

- the dead weight of the conduit,
- the weight of the fluid passing through the conduit,
- 5 - the pressure to be established in the conduit (particularly a forced conduit),
- the possible overpressures arising as a result of the use of hydraulic appliances (valves, etc.),
- the hydrostatic pressure of a body of water in which
- 10 the conduit may possibly be submerged,
- the load of the embankments where the conduit is buried,
- permanent overloads possibly existing on the embankments,
- mobile overloads possibly pressing the embankments,
- variations in temperature and in moisture,
- 15 - bearing reactions, etc.

As mentioned in the introduction, it is expedient to obtain a profile, the lower part of which is somewhat flattened and the upper part of which corresponds to a curve resulting from the best possible stress calculation.

- 20 The second step involves dividing the best possible cross-sectional profile so obtained into adjacent portions, each corresponding to a longitudinal element, such as A1, B1, etc., and together providing a substantially continuous inner surface designed by S in Figure 5.

- 25 The third step involves giving the cross-section of at least some of the said elements a variable thickness in order to adapt it to the stresses exerted at the various points of the cross-section of the element in question. Thus, Figures 6 and 7 illustrate cross-sections
- 30 through conduit elements, showing how the thickness of material can vary. This characteristic is extremely important in terms of both the production and the transport and assembly of the element, since the quantity of material and consequently the weight and the cost price
- 35 are defined as exactly as possible as a function of the parameters governing the production of the final conduit. If the use of the invention for the construction of oil pipelines, aqueducts, etc., of considerable lengths is



considered, the influence of a gain in weight on the final work profitability of the structure will easily be appreciated.

The conduit elements according to the present invention can consist of various materials and can correspondingly be manufactured by various processes. Thus, it is possible to consider producing elements such as A1, B1, C1, etc., from a metal, such as ductile cast iron, spheroidal graphite cast iron, steel, aluminium alloys, etc. For such materials, it is possible to carry out various processes such as, for example, piece casting, continuous casting, extrusion, forging, differential rolling, etc. All these processes make it possible to produce uniformly recessed or projecting parts which subsequently, during the assembly of the elements, will serve for forming longitudinal and transverse joints, as will be explained specifically later.

It is also possible to produce conduit elements from materials other than metals, especially reinforced concrete, plastics or resins reinforced or not by fibres, etc. Under such conditions, the elements are produced by casting by means of moulds or formwork which also make it possible to obtain the abovementioned projecting and recessed parts.

All the processes using the abovedefined materials for producing the conduit elements according to the invention involve dies, moulds, formwork, etc. which must take into account the characteristics of the process for obtaining conduits according to the invention under the following conditions:

- the inner surface of the conduit element produced must correspond to the best possible cross-sectional profile of the conduit determined by calculation as a function of the known parameters relating to the type of installation, the conditions of use of the conduit and its inherent characteristics.
- Where a conduit where the external conditions



vary only slightly is concerned, the expression "best possible profile" means an average profile applicable to this conduit over a certain length,

- each element must have the overall dimensions allowing it to be assembled together with the other elements of the conduit, and the various thicknesses of the elements must be calculated so as to allow them to withstand the stresses to which they are subjected.

Final sealing is obtained by various means suitable for each material used and is effected from the inside of the conduit after final stabilization (subsidence, compensation of expansions, compacting, etc.).

How the various elements are assembled together to form a conduit will now be described by reference to Figures 8 to 12 which give some exemplary embodiments of longitudinal joints and transverse joints. Thus, Figure 4 shows, in cross-section, a longitudinal joint made between the two conduit elements A1 and B1. Here, on either side of the points defined by the two surfaces 71, 72 of the elements A1, B1, there are respective outer longitudinal ribs 73, 74 which extend over the entire length of the corresponding conduit elements. These ribs can be formed during the casting, extrusion, rolling or moulding of the corresponding elements or they can also be attached by welding, in which case they can be discontinuous. As shown in Figure 8, these two ribs make it possible to fasten a locking stirrup 79 simply and effectively by means of wedges 76, 77 which are fitted in position between the stirrup and the corresponding rib, for example by hammering or by any other similar process.

In order to absorb the reactions exerted in a direction perpendicular to the cross-sectional profile of the conduit, it is expedient to give the surfaces for the lateral delimitation of the conduit elements A1, B1, etc. forms which allow them to absorb the stresses in the best



possible way, in view of all the parameters relating to the conditions of production and use of the conduit and also of the material of which it is made. Thus, Figures 8, 9, and 10 give, as non-limiting examples, some models of profiles of the said lateral surfaces for the delimitation of the conduit elements. In Figure 8, the delimiting surfaces 71 and 72 are inclined relative to the plane perpendicular to the cross-sectional profile of the conduit. Such a profiling of the surfaces of the joint is suitable, for example, when the static loads exerted on the conduit are predominant.

In Figure 9, the two surfaces for the lateral delimitation of the conduit elements A1, B1, designated by 79 and 80, have corresponding rounded forms, so as to absorb reactions exerted in both directions in the said plane perpendicular to the cross-sectional profile.

Figure 10 shows delimiting surfaces 82 and 83 which form steps making it possible to obtain an interlocking.

Figures 11 show profiles 33 and 34 defining a cell 35 which can be filled with a sealing material, for example a cast resin.

It should be noted that all these forms of the lateral surfaces for the delimitation of the conduit elements can be obtained perfectly by any of the above-mentioned production processes. To ensure good sealing, in each case there are, between the corresponding surfaces of the abovementioned longitudinal joints, coatings, mastics, gaskets or other agents for ensuring sealing, especially made of natural or synthetic rubber, as indicated respectively at 8 in Figure 8, at 81 in Figure 9 and at 84 in Figure 10.

It should be noted, in this respect, that these joints ensure sealing under pressure.

Figure 14 illustrates a longitudinal joint which is formed between two conduit elements A1, B1 produced from reinforced concrete. The respective reinforcements of the elements A1, B1 are designated by 20 and 21. To make



the junction, the reinforcements 20,21 are allowed to project during the casting of the elements, and once these have been installed in the intended positions at the place of installation of the conduit, the projecting end parts of the respective reinforcements are connected to one another, as indicated at 22, and then, using suitable formwork elements, such as 26, a bedding mortar is poured at 23 into the existing gap, in order to obtain the intended longitudinal joint.

Figure 14 shows at 24 and 25 angular and recessed profiles of the connecting edges of the elements A1,B1. These profiles are intended, on the one hand, to make the bonding of the bedding mortar 23 easier and, on the other hand, to complete the sealing of the joint by providing discontinuities serving for eliminating localized leakage paths. 27 and 28 denote members for the retention of the formwork 26 which is fastened in position by means of the nuts 29, 30.

Figure 12 illustrates an exemplary embodiment of a transverse joint between two conduit portions consisting respectively of elements such as A1, etc. and elements, such as A'1, etc. The delimiting surfaces of the transverse joint are designated by 15 and 16. In the example in question, there is a peripheral joint designated as a whole by 17 and comprising, on the one hand, a radial moulding which engages into the gap present between the surfaces 15, 16 and, on the other hand, a peripheral ring, the inner surfaces of which are laid against the outer surfaces of the respective conduit elements, the said ring having, on its outer peripheral surface, relief parts 19 intended to be flattened as a sort of compression by means of a strap or collar 18A, 18B, as shown in Figure 13 which is a cross-section through the conduit of Figure 12. In the example under consideration, given as a non-limiting indication, the relief parts 19 can have a dovetail profile and possess partitionings in their notches to provide a joint of the labyrinth type. The flattening strap is produced in two parts 18A,18B connected to one another by means of



tensioners 31,32 which are actuated for the purpose of final clamping.

It should be noted that, although all the exemplary embodiments of joints between conduit elements do not involve any bolting, such a process is not entirely excluded, and that it is possible to form or fasten on the elements parts similar to rims and flanges which would subsequently be assembled together by means of bolts or similar members.

In some uses, it is possible, within the scope of the invention, to adopt a composite structure for the conduit, that is to say use, on the one hand, elements formed from a first material, for example reinforced concrete, in a first part of the conduit, for example in the lower part located between the longitudinal joints JL1 and JL4 in Figure 5, and, on the other hand, elements formed from a second material, for example a metal or a plastic reinforced or not with fibres, in the remaining part of the conduit. Such a composite structure can be recommended in an open-trench water-supply structure, that is to say one without high loads on the top of the conduit, in a remote region where it is viable to manufacture the lower part from cast reinforced concrete and the upper part from thin elements prefabricated at the factory and transported to the site.

Figure 15 represents by unbroken lines the form of the neutral axis of a cross-section of a conduit according to the invention (curve I), by broken lines (curve II) for the distribution of the bending moment corresponding to the vertical thrust of the earth and by dot-and-dash lines (curve III) the distribution of the bending moment corresponding to the lateral thrust of the earth. The complete calculation also includes the determination of a certain number of similar curves corresponding, for example, to the internal pressure, the dead weight of the conduit, etc. The calculation then involves combining the results which each correspond to a particular type of stress.



It can be seen that the complete profile of the cross-section comprises four "node" zones located one in the lower part of the conduit and the other towards its upper part.

5 Figure 16 shows a half-section of a conduit formed from four reinforced-concrete elements.

It can be seen that the thickness (h_1 , h_2) in the zones corresponding to the highest stresses of Figure 15, that is to say the centre of the base and on the sides, is approximately 50 % greater than the thickness h_3 at the top. The junctions JL1, JL2 between elements have been formed in the zones of stress nodes. In this Figure, the reference f_1 denotes the reinforcing bars embedded in the concrete of the elements prepared in advance and f_2 designates the anchoring bars which have been bent onto one another, before being embedded in the concrete, during the building of the structure.

Figures 17 shows an exemplary embodiment designed for conduits of relatively small cross-section: approximately 1.5 to 4 m². For the sake of simplification, the cross-section of the conduit is divided into two elements which can be transported separately without particular difficulty because of their small dimensions. The lower element 40 is made of concrete and obtained by casting, and it comprises the base with a flat bottom and the sides. It will also be seen that it possesses stabilizing elements 41 which are integral with it and which allow it to be installed easily in a trench with a flat bottom. These stabilizing elements are volumes with a cross-section of general triangular form, with a horizontal lower face, these stabilizing elements, not extending over the entire length of the element 40 in order to save weight. The upper element 42 of the conduit is of simpler form, because it has the shape of an upturned gutter of low curvature. It can be produced either by casting or by extrusion. If the lower element 40 is produced by extrusion, it is clear that the stabilizing elements 41 are fastened subsequently, but before the installation of the



conduit, by screwing, welding or any suitable means.

In Figure 16, a stabilizing element 41 has been represented by broken lines. This Figure reveals another advantage of the stabilizing element with regard to a structure of which the cross-section is formed from more than two elements. In fact, it can be seen that the side element A2 equipped with the outer stabilizing element 41 can remain alone in the final position. There is therefore no need to provide a temporary support during the execution of the junction JL2 with the base element A3.

It will also be seen that, where a structure placed on the ground is concerned, the stabilizing element increases the resistance to the lateral forces tending to upset the structure, this being advantageous in respect of a nuclear shelter or the like placed on the ground and exposed to blasting effects.

Figure 18 shows an embodiment of sealed joints where the elements are made of material neither weldable nor adhesively bondable, for example concrete:

Each element A1, A2 carries, on its edges, brackets 43 made of weldable or adhesively bondable material, for example ferrous metal, which are put in place during casting if the element is obtained in this way. Flat elements 44 or other flat connecting elements made of material weldable or adhesively bondable to the brackets 42 are welded or adhesively bonded to these, if appropriate after the stabilization of the ground.

Figure 19 shows another means of assembling the structures according to the invention.

One of the elements A1 has a threaded hole 45 which can be made in an insert 46. This threaded hole is directed approximately perpendicularly relative to the plane of the joint. The other element A2 has a shoulder 47 pierced with a hole 48, into which is inserted a screw 49 screwed into the hole 45 and passing through the hole 48 with play.

Figure 20 shows another embodiment for joint sealing, in which the concrete elements A1, A2 are equipped



on the inside with a sheet-metal sealing covering 50 constituting an expendable formwork. An inner flat element 44 is then welded directly to this covering 50. A bracket similar to that of Figure 18 can be provided
5 on the other edge of the elements A1, A2.

It is pointed out that a certain number of assembly arrangements described above are used for the installation of the conduit and are not themselves alone involved essentially in containing the hydrostatic pressures when the conduit is used as a forced conduit, these
10 hydrostatic pressures partly being compensated by the thrust of the embankments.

In order to secure the elements of a conduit, shelter or the like to one another more effectively and make it easier to construct it at particular points, if
15 appropriate, there can be, in addition to the prestressing cables forming a strap, prestressing cables or bars connecting together longitudinal elements adjacent to one another in a longitudinal direction. These cables or bars
20 can each connect at least two consecutive elements to one another, for example, one element can be connected to the element following it by means of one set of cables or bars and to the element preceding it by means of a similar set, thus making it possible to exert the prestress progressively at the rate of advance of the installation. It is
25 also possible for each prestressing cable or bar to connect three consecutive elements or even more to one another.



CLAIMS

1. Process for obtaining a conduit, limited by a cylindrical wall, not of revolution, by the assembly, on the spot, of longitudinal elements prepared in advance, each corresponding to part of the cross-section of the wall and bearing on one another along longitudinal joints (JL), so as to form adjacent portions each consisting, in cross-section, of at least two elements, namely a lower element (40) with a flat bottom, forming the base, resting on the ground and at least one curved upper element forming an arch, characterized in that a prior calculation of the stresses of the structure as a whole is made, taking into account all the known parameters relating to the installation site, the conditions of use and the inherent characteristics of the conduit; according to the result of this calculation, the form of the longitudinal elements (40,42), which are elements without corrugations, is determined so that the longitudinal joints (JL) between adjacent elements are in the vicinity of "stress nodes", that is to say points where the absolute value of the stresses transverse relative to the wall passes through a minimum, then a calculation of the stresses is carried out element by element, and according to the result of this calculation the exact form of the curvature, the thickness of the cross-section and the material of each element are determined.

2. Process according to Claim 1, characterized in that the cross-section of the elements (A1,B1) is given a thickness (e) which varies along the lines of this cross-section, so as to adapt this thickness to the stresses exerted, such as a result from the said calculation.

3. Process according to Claim 2, characterized in that, when the conduit elements (A,B) are produced by integral casting or by continuous cross-sectional shaping, particularly by extrusion, of materials, such as ductile cast iron, steel, reinforced concrete, etc., the mould or die used is of a cross-section which is shaped so as to reproduce, on the inner surface of the conduit element,





the abovementioned portions of ideal profile and also the transverse variation in the thickness.

4. Process according to one of Claims 1 to 3, characterized in that longitudinal elements without corrugation, together providing a continuous inner surface, are used.

5. Process according to one of Claims 1 to 4, characterized in that the structural joints according to the invention are not in an alternating arrangement, but on the contrary the longitudinal joints (JL) are in the extension of one another on either side of each transverse joint (JT).

6. Process according to one of Claims 1 to 5, characterized in that elements of different materials are used for the different longitudinal elements (A,B), the necessary precautions being taken to prevent corrosion as a result of the electrochemical contact effect.

7. Process according to Claim 6, characterized in that the elements (40) of the lower part of the cross-section of the conduit are made of cement and the elements (42) of the upper part are made of metal.

8. Process according to one of Claims 1 to 7, characterized in that the initial assembly of the elements (4,5) is carried out in a way allowing a limited relative movement of the adjacent elements, and in that a final assembling together of the elements is carried out subsequently.

9. Process according to Claim 8, characterized in that the initial assembling together of the elements is carried out by means of bolts (12) passing through at least one of the elements via a widened hole (9,10).

10. Process according to one of Claims 1 to 9, characterized in that, to carry out the longitudinal junction of the conduit elements (A1,B1), recessed parts (25) or projecting parts (24) are formed, these being located in the zones of the corresponding edges and being capable of interacting by a matching of forms and/or forces in order to produce the necessary longitudinal joints.

11. Process according to one of Claims 1 to 10, characterized in that, to obtain a longitudinal joint between two elements (A1,B1) produced from reinforced concrete,





reinforcements (20,21) are allowed to project during the casting of the elements, these are installed in the intended positions at the place of installation of the conduit, leaving a gap in which the projecting end parts of the respective reinforcements overlap, and then, using suitable formwork elements (26), bedding mortar (23) is poured into the existing gap, in order to obtain the longitudinal joint.

12. Process according to one of Claims 1 to 11, characterized in that, to obtain longitudinal joints (JL), a rib (73,74) is formed on each of the edges of two elements (A1,B1) to be joined, and clamping means (75) are distributed along the two ribs (73,74) so formed.

13. Process according to Claim 12, characterized in that the said clamping means are stirrups (75).

14. Process according to Claim 13, characterized in that the stirrups (75) are fastened by means of rigid or elastic pieces (76,77) fitted between the inner surface of the stirrup (75) and the flank of the corresponding rib (73,74).

15. Process according to Claim 13, characterized in that the stirrups (75) are fastened to the ribs (73,74) as a result of the rigid [sic] deformation of the stirrups themselves.

16. Process according to one of the preceding claims, characterized in that a gap is left between the delimiting surfaces (15,16) of the transverse joint between two adjacent elements (A1,A'1) belonging to two successive portions of the conduit.

17. Process according to one of the preceding claims, characterized in that, to obtain the sealing of the conduit under pressure, gaskets (81,83) are interposed between the edges of the longitudinal joints (JL) and/or transverse joints (JT) and are of a cross-section shaped to correspond to the said edges.

18. Process according to Claim 17, characterized in that the sealing clamping of the gaskets is obtained by means of stirrups (75) bearing on the ribs (73,74)





provided on the mutually opposite edges of two elements (A1,B1) to be joined or by means of collars, straps of other means.

19. Process according to one of the preceding claims, characterized in that, when the elements are formed from weldable or sealable materials, the longitudinal joints (JL) are made by the addition of the corresponding weldable or sealable material (23).

20. Process according to one of the preceding claims, characterized in that, when the elements are formed from weldable or sealable materials, the transverse joints (JT) are made by the addition of the corresponding weldable or sealable material (23).

21. Process according to one of the preceding claims, characterized in that, after the assembly of the longitudinal elements, a prestressing of the conduit in the longitudinal direction and/or in the transverse direction is carried out before or after the conduit is put into operation.

22. Process according to one of the preceding claims, characterized in that, for improved sealing, there is a covering (50) or a lining or leakproof lining integral or not with the elements (A1,A2) of the structure.

23. Process according to Claim 22, characterized in that the inner covering forms an expendable formwork part (50) for the elements of the structure.

24. Process according to Claim 23, in which the inner covering is made of a weldable or adhesively bondable material, characterized in that, in the region of the joints (JL,JT) between elements, the sealing is obtained by welding or adhesively bonding to the parts of the covering (50) flat pieces (44) made of a material compatible with that of the covering (50).

25. Process according to Claim 23, in which the inner covering is made of a weldable or adhesively bondable material, characterized in that the covering parts are welded or adhesively bonded directly to one another in the region of the joints (JL,JT).





26. Process according to one of the preceding claims, characterized in that, for the assembly of the elements of the structure, in one element (A2) there is a threaded hole (45) approximately perpendicular relative to the plane of the joint, and in that screwed into this hole is a threaded rod (49) inserted into a hole (48) of the opposite element (A1).
27. Process according to one of the preceding claims, characterized in that ballast masses or anchoring elements are fastened by bolting under the base (40) of a flattened form of the conduit.
28. Process according to one of the preceding claims, characterized in that, for the changes in direction of the conduit, specially calculated and designed curved or canted prefabricated elements are used.
29. Process according to one of the preceding claims, characterized in that at least two longitudinal elements adjacent in a longitudinal direction are connected to one another by means of prestressing cables or bars.
30. Process according to Claim 29, characterized in that each element is connected to the element following it by means of one set of prestressing cables or bars and to the element preceding it by means of another set of prestressing cables or bars.
31. Process according to one of the preceding claims, characterized in that, to make the installation and stabilization of the conduit easier, there are placed on the sides of the lower face of the latter stabilising elements (41) which have a horizontal plane face approximately level with the bottom of the conduit.
32. Process according to one of the preceding claims, characterized in that, each portion of the conduit comprising two side elements (A2) of general vertical orientation, stabilizing elements (41) are placed at the base of the said side elements (A2), allowing the said side elements (A2) to stand upright by themselves when they rest on the ground.
33. Process for producing a conduit according to one of





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preceding claims, characterized in that, to produce a portion of the conduit, two side elements (A2) equipped with stabilizing elements (41), allowing them to stand upright by themselves when they rest on the ground, are installed, and then the upper element (A1) is placed on the said side elements (A2).

34. Process for producing a conduit according to Claim 33, characterized in that the junction between the lower edges of the side elements (A2) and the bottom (A3) is made before the upper element (A1) is placed on the side elements (A2).



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