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(54) A PROCESS AND APPARATUS FOR THE MANUFACTURING OF TUBULAR MEMBERS MADE OF PROJECTED CONCRETE, WITH AN EVENLY DISTRIBUTED REINFORCEMENT, AND PRODUCTS THUS OBTAINED

(71) We, VIANINI S.P.A., an Italian Joint Stock Company, of 25 Via della Ferratella in Laterano, 00184 Roma, Italy, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention refers to a process and to an apparatus for the manufacturing of a product consisting of a tubular member made of projected concrete, with an evenly distributed steel reinforcement, obtained by continuously projecting or throwing a concrete jet on a rotating tubular core (either to be thrown away or to be re-used), and simultaneously and continuously winding small-diameter steel wires on said core, in such a way as to realize a reinforcement embedded in concrete.

In the specification and claims, by the term "projecting" and "projected concrete" it is meant an operation of throwing a directional jet of concrete with a high momentum and a high impact force and the concrete body thus formed, respectively. By the term "evenly distributed reinforcement" it is meant that in any cross-section of a reinforced concrete body or member, the reinforcement steel wires appear to be distributed or spread all over in a uniform and finely divided pattern on said cross-section.

The product obtained through this process presents a number of characteristics that are not found in similar products made using the previous technique, and thus represents a new industrial product.

As it is well known, the concrete pipes destined for pressure conduits are divided into two distinct groups:

a) reinforced concrete pipes;

b) prestressed concrete pipes.

The former group, used in a comparatively moderate pressure range (for example, for diameters of about one metre, not exceeding 5—6 atmospheres) consists of a concrete wall with embedded circumferential and longitudinal reinforcement round bars of a comparatively large diameter; they are manufactured using various technologies (associated or non associated centrifugation with vibration or rolling, casting on vibrating vertical moulds etc.).

The latter group, to be asked for a pressure range higher than that of the reinforced concrete (and hence from 5—6 atmospheres up to a maximum of about 20 atmospheres) usually consists of a core, made according to one of the technologies used for pipes made of reinforced concrete, around which a high tensile steel spiral in tension is wound; the spiral is then protected by means of a concrete lining and, almost always, of a further bituminous lining.

A special type of prestressed pipes is represented by monolithic pipes, with tensioned steel reinforcements embedded in the wall at the time of casting.

Pipes with metal sheet embedded in the wall, of both the reinforced and prestressed type, are finally used: but these pipes are no longer in common use at least in Italy, owing to their excessive cost.

From the short description of the technologies used for manufacturing the above mentioned pipes, there clearly emerge the following shortcomings of such technologies, which, once eliminated, will turn into as many advantages for the manufacturing process described in the present invention:

a) the pipes presently sold on the market pass through a number of processing phases; in particular, and with regard to the pipes made of reinforced concrete: the manufacturing of reinforcement, the preparation of the mould, the manufacturing of the pipe, the curing of the pipe, the extraction of the pipe from the mould; with regard to prestressed concrete pipes, the said operations must be supplemented with the winding with steel in tension, concrete lining, bituminous lining. Each operation requires a specific equipment and a special department; a complex handling is also required for moving the products from one department to the other. The advantage thus becomes apparent of a process in which all the manufacturing operations are combined in one single machine.

b) The various operations for the manufacturing of the pipes presently commercially available must be obviously peformed in successive phases (the manufacturing of the pipe after the construction of the reinforcement, the winding of steel after the pipe curing, etc.): this involves both a considerable waste of time in between the various operations, and the accumulation of stocks of products under construction: moreover, within a same phase, such as the casting of the pipe's wall, the two phases of distribution and compacting of material take place in succcessive stages, what involves a more protracted period of use of the machines. Thus the advantage clearly emerges of a method, such as the one described in the present invention, whereby all the phases (reinforcement, distribution and compacting of concrete, curing of same even partial, are performed not only on the same machine but also simultaneously.

c) The plants for the production of reinforced concrete pipes and of those made of prestressed reinforced concrete, basically differ from each other; in practice, what they have in common is only the department where the concrete is made, and that where the pipe is formed and cured: it ensues that not all the plants in existence are equipped for producing pipes for the whole range of concrete applications; conversely, those plants which are equipped for such a range of applications, white often fail to exploit their machinery in full. The process envisaged by the present invention allows, instead, to manufacture pipes for working pressures so high that they fully encompass both the reinforced concrete pipes and the prestressed concrete pipes: the plant; therefore, although quite simple, affords possibilities of use that remarkably exceed those of the plants in existence.

d) The plants working according to the known processes require a very large number of moulds: for each diameter of the pipes to be manufactured, at least three sets of moulds are needed: one for low pressures (for example, 1 to 3 atmospheres) reinforced concrete pipes, one for higher pressures (for example, 4 to 6 atmospheres) reinforced concrete pipes, and one for prestressed concrete pipes (dissimilar from the previous ones because of the reduced thickness of the pipe wall, of the shapes and inclinations of the conical surfaces that must allow the prestress spirals to be wound around the pipe, of the devices inserted to allow longitudinal prestress etc.). Such a division of the available moulds of each diameter is quite usual, although it represents a compromise that in no way prevents a waste of material (for example, a 4-atmosphere pipe must necessarily be manufactured with the same thickness as for the 6-atmosphere pipe, whilst it could be thinner). If one considers that to realize a continuous manufacturing cycle of pipes of the same type and having the same diameter, no less than 10—12 moulds are required (in view of the long period of time each mould is used for the application of reinforcements, for the casting of pipes, for the curing and demoulding), it must be concluded that no less than 30—60 moulds are needed for each diameter of pipes: in practice, the number of moulds required, which is reduced by the common practice of manufacturing pipes of a different diametre in the same working shift, is always very high. The manufacturing process according to the present invention allows, instead, to manufacture any type of pipes using only three cores per diametre, in view of the rapid cycle determined by the simultaneous performance of all the operations, and of the almost immediate recovery of the core; moreover, each pipe can be manufactured adjusting the thickness exactly to the working requirements envisaged for it, without any modification of the core and without any waste of material.

e) The moulds mentioned above (very complex structures, because of the joints, shapes, rolling rings, stiffenings, etc.) have a fixed manufacturing length and usually socket-and-spigot ends; the manufacturing of pipes of a different length, or with differently shaped ends, involves either other moulds or at least parts of moulds, which, through bolted flanges, may be replaced to the corresponding parts of the socket-and-spigot moulds; all this brings about a further increase in the number of moulds, a complication of the same moulds, and a considerable waste of time as a result of the transformation works. It is therefore convenient a manufacturing process that, like the one envisaged by this invention, allows instead to realize any pipe length and any shaping of ends, without in any way intervening on the cores.

Attempts were made in the past to manufacture reinforced concrete pipes with evenly distributed reinforcement by projecting concrete on a rotating core (see Italian Patent No. 567,318 issued 11th February 1957 and corresponding British Patent No. 1,837,243 issued 28th September 1960).

This attempt is well known to the Applicant, in that it was performed in a plant owned by the Company; it is a well-known fact that this attempt led to no practical results, so much so that there exists at present no type of reinforced concrete pipe manufactured according to a projecting process, whereas prototypes perfectly in line with the characteristics required for pipes destined for pressure conduits, have already been successfully manufactured and tested, using the method envisaged by the present invention.

Listed hereunder are the drawbacks of the process described in the above patent, which have made its practical application impossible:

1) No unit was envisaged for controlling the amount of concrete to be projected; as a result, the feeding of the projecting device was extremely variable. To overcome this inconvenience, or to reduce its effects, a concrete was used with a high water to cement ratio, thus precluding, in the very early stage of manufacturing, the production of a type of concrete with high mechanical characteristics.

2) The projecting device was of the paddle type (thus of non-continuous operation and not able to produce a continuous jet): it was not capable of imparting a high kinetic energy to the material, and this determined not merely an insufficient concrete compactedness, but even the falling down of the material from the core.

3) In particular, the projecting device caused a selection of the mix; some of the thinner material, projected with a reduced energy, could not even reach the core or fell down as it reached the surface of it; this involved the necessity of using mixes very rich in cement and sand, to allow for the waste (of a very variable amount; hence, the characteristics of the concrete of which the pipe was made also differed from pipe to pipe, and even from site to site on the same pipe).

4) The feeding with a mix very thin, very rich in cement and water, caused a gradual clogging of the surfaces of the projecting device, in spaces in between the paddles, that were drowned in the mortar: after very short periods of use, the concrete spray tended to become deformed, with the consequence that an altogether irregular deposit of material gradually formed on the core in lieu of a continuous helicoidal band; if the operation was continued, the flow of concrete rapidly decreased and the projecting had to be stopped for cleaning the projecting device.

5) The drawbacks listed so far were responsible for the formation of scarcely compacted concrete layers, whose thickness was absolutely irregular; so the use of a device (practically, a worm hob) to level the mixture, layer by layer, before the application of the reinforcing wires on each layer, was regarded as indispensable.

6) The presence of the levelling device ruled out the possibility of an uninterrupted projecting of concrete, with a back and forth movement; the projecting device could therefore work in one direction only, and not in the other sense.

7) Again as a result of the presence of the levelling device, also the winding of the reinforcement wires had to take place in single runs; the adoption of continuous wires, as envisaged in the present invention, would not have been possible; the adoption of these continuous wires was not therefore envisaged in the prior art patent.

8) After each run with the device for distributing the reinforcement wires, the wires were to be anchored (using provisional means, such as metal keep plates, screws, etc.) on the end of the core and then cut; the projecting device was to be brought back to its initial position for the successive run, and here the ends of the wires were to be fixed again, using the same means as before, on the other end of the core; only after the performance of these operations, the successive run could take place.

9) Moreover, in levelling the concrete surface, the leveler inevitably caused a disgregating action on concrete, reducing its compactedness and thus impairing its resistance and impermeability.

10) the reduced consistency of the original mixture, further worsened by the use of the leveler, caused the wires to penetrate the concrete, instead of lying on it; in this way, the very distribution of the reinforcement wires was irreparably altered, with anomalous wire concentrations in some sites, and leaving other sites without reinforcement; the already impaired resistance of the material was thus further prejudiced.

11) The use of the levelling device also determined a enormous waste of material, removed when the concrete was levelled; the thinner the layer of the levelled concrete, or the more distributed the wire reinforcement (in order to exploit the theoretical possibilities of the method), the more material was wasted.

12) Finally, the problem of the longitudinal wire reinforcement of pipes was in no way solved, whereby further interruptions were envisaged of the manufacturing cycle, during which the necessity emerged of manually laying large diametre wires, anchored at the ends of the core over the already projected concrete, in order to ensure that they were duly covered by the successive layers of material.

13) Finally, nothing had been done for shaping the ends of the pipes, in order to allow the jointing with a simple and economic systm (for example, with the socket and spigot type); the method — even if used on an industrial scale — would have allowed to produce only cylindrical pipes with smooth ends, that would have required the use of expensive box couplings or of Gibault type joints to be manufactured in a separate plant, with exceedingly high costs; no less costly and complex would have been the laying and jointing of these pipes.

For the above mentioned reasons (reduced concrete resistance, high porosity and permeability, irregular arrangement of the steel reinforcement, waste of material, excessive duration of the cycle, etc.), the method described in 1955 never had any practical application, as previously said.

The object of the invention is, therefore, to provide a process and an apparatus for manufacturing, in a technically feasible and economically valid manner, tubular members made of reinforced concrete, with a reinforcement of small diameter continuous wires, arranged according to coaxial, concentric, continuous helixes.

An object of a preferred embodiment of the invention is to realize a device for the dosage of batches, in order to ensure the perfect feeding of the projecting device, even with an extremely consistent and dry concrete, characterized by a slump value equal to zero.

Another object of a preferred embodiment of the invention is to realize a projecting device capable of ensuring the uniform distribution on the core (without the use of levelling devices) of the above mentioned material, layers even of an extreme thinness, immediately self-supporting, of such a consistency as to support the application of the reinforcement wires, and with a high resistance and impermeability.

Still another object of a preferred embodiment of the invention is a reinforcement wire distribution device, capable of simultaneously applying many bundles of wires, also with different functions, in such a way as to eliminate, among the other things, the longitudinal reinforcement wires, and to replace them by bundles of wires wound with a suitable inclination in respect of the axis of the manufactured product.

A further object of the invention is to provide a process and apparatus to attain concrete projection and the distribution of the steel reinforcement at the same time.

A further object of the invention is a process and apparatus for performing said operations in a continuous form, with back and forth movements all utilizable and therefore without any shut down, in particular, without cutting the reinforcement wires on each run.

Still another object of a preferred embodiment of the invention is a process which enables subjecting the pipe to a quick curing, even while it is formed, thus minimising the dead times in between the two successive re-uses of the same core.

According to the invention there is provided a process for manufacturing a tubular member consisting of a wall of projected concrete, strengthened with a continuous evenly distributed reinforcement, in any desired thickness, which process includes the operations of preparing a concrete mixture with such a water-cement ratio as to present a characteristic substantially of slump zero; adjusting the flow rate of the said concrete mixture in order to obtain an essentially steady flow rate; projecting said concrete mixture continuously and in a steady flow rate, in the form of a thin laminar jet of a substantially uniform width, at a high impact speed, on the external surface of a first present concrete tubular layer projected on a tubular core rotating around its axis; causing the point of impact of the said jet against the surface of the said first tubular layer, to move along the longitudinal axis of the tubular core, while applying on the surface of the first tubular layer, simultaneously with the said projecting operation, at a point constantly ahead of the point of impact of the jet, an helicoidal winding of reinforcement wire, in such a way that the said projected concrete produces a self-supporting concrete layer, which covers and embeds the said reinforcement wire winding and which adheres to the said first tubular layer; repeating in the opposite direction and with continuity, the said operations of wire winding and of concrete projecting every time that the jet reaches an end of the tubular core, until the wall of the tubular member has the desired thickness, this wall being thus made of a monolithic concrete mix embedding a set of concentric, coaxial, helicoidal windings of continuous metal wire.

According to a further aspect of the invention there is provided an apparatus for the manufacturing of a tubular member, including a station for the batching and mixing of the concrete components for making the mixture; facilities for the transportation of the mix; a unit for projecting the concrete, movable with a back and forth movement, and a core rotating around its longitudinal axis, placed with said axis parallel to the direction of the back and forth movement of said projecting unit, at such a distance as to receive on the surface the concrete jet projected by said unit; one or more reels for distributing the reinforcement wire, said wire being fed with a traverse movement and wound in a helicoidal pattern around the axis of said core; said apparatus being characterised by the fact that the concrete projecting unit includes a device for controlling the concrete flow rate, which steadily feeds a projecting unit consisting of a pair of rolls rotating at a high speed, placed on axis parallel to one another and parallel to the axis of the core, said rolls rotating at a peripheral contact with each other and being made of or lined with an elastomeric material, in such a way as to project a steady laminar concrete jet with a high kinetic energy on said core.

A process according to the present invention, is hereinafter described.

In a central batching and mixing station, the concrete of a suitable composition is prepared. The concrete should be such as to be projected or thrown without undergoing any phenomena of parting out of its components; it should form on the core homogenous, compact and uniform layers of a very reduced thickness (as reduced as to 2—3 mm at a minimum); it should become self-supporting as soon as it is projected on the rotating core to prevent detachment or falling-off phenomena; it must be made compact on the core as a result of the projecting operation, in order that it may support the load of the reinforcement wires without being cut off by them; finally, it must present — once it is finished — such high values of mechanical resistance and of highly reduced porosity and permeability, as required in pipes destined for pressure conduits.

According to the invention, these requirements are met through a suitable study of granulometric mixtures (varying, on the other hand, according to the nature of the stone material), with a high cement content and with a greatly reduced water/cement ratio (slump value substantially equal to zero), but chiefly through devices controlling the concrete flow rate, and through the special projecting operation that allows to convey the material to the core in a continuous flow, absolutely uniform, extremely thin (a thickness of the order of a few mm) and of a constant width (of an order of several cms.), whose velocity, on the point of projection, is very high (never lower than 60, preferably not lower than 70—80 km/h), and capable of ensuring — also considering the characteristics of the material — the immediate compacting of same on the core surface.

During the projecting operation, a carriage with the above mentioned devices, is made to longitudinally run, back and forth, parallel to the axis of the core. This movement, suitably coupled with the rotation of the core, allows to distribute the concrete in adjacent helicoidal bands, forming a continuous layer of concrete laid on the core on each movement made by the carriage; the number of runs, and hence the number of concrete layers or, in other words, the thickness of the pipe to be manufactured, can be varied as many times as desired, according to the resistance requirements of the pipe. The process so far described thus allows — all the inner diametres of the pipe being equal (equal to the diametre of the core) — to manufacture pipes of all thicknesses.

Concomitantly with the back and forth movement of the carriage, laying the successive concrete layers, a similar movement, which can be referred to as a traverse movement, is performed by one or more reel-holding carriages; each of these reels contains a small-diameter steel wire (practically less than 3 mm aproximately); these wires pass through a comb and are anchored to an end of the core and wind around the concrete layer on the core in an helicoidal pattern. On completion of a run of the carriage, the bundle of wires, which has reached the end of the pipe to be manufactured, begins without any interruption or shut down, that is, without cutting the wires, the backward movement, forming the reinforcement of the successive concrete layer.

A more detailed description of the invention is illustrated referring to the accompanying drawing, which schematically represents an apparatus for an embodiment of the process according to the invention.

The manufacturing apparatus includes:

A) a station 1 for the batching and mixing of the concrete components, where the mixture is prepared in accordance with the required characteristics;

B) a conveyor 2, for instance, of the belt type, for conveying the prepared mixture (which is referred to hereinafter as "concrete");

C) a unit 3 for controlling the concrete flow rate and projecting the concrete, which receives said concrete from said conveyor 2, which is mounted on a carriage 4, to which a back and forth movement can be imparted, for a run equal to the length of the product or pipe to be manufactured;

D) a cylindrical core 5, with a diameter equal, and with a length at least equal, to those of the pipe to be manufactured, rotating on its own longitudinal axis, and with said axis parallel to the travel direction of the carriage 4, at such a distance as to receive on its surface the concrete projected by the control and projecting unit 3;

E) a second carriage (that, for purposes of simplification, is not shown separately in the drawing but is coincident with the carriage 4, it being understood that, conceptually, the carriage for the control and projecting unit and the reel carriage for the traverse movement can be regarded as separate), which carries the reels 6 (indicated in a schematic way), on which those steel wires are wound, that are destined to form the reinforcement of the pipe; it can make a back and forth traverse movement similar to that of the concrete projecting carriage (or coincident with it, as shown in the figure);

F) a plant for the production of steam or heat for a quick curing (not shown); and

G) lifting and transportation facilities (not shown).

In operation, the concrete, proportioned and mixed by means of equipment 1, is conveyed by conveyor 2 and fed to the control and projecting unit 3, which projects a thin laminar jet of concrete, which may be preheated, on the tubular member which is gradually formed all round the rotating core 5, whilst carriage 4 moves parallel to the core axis. After a first layer of concrete is laid on core 5, the ends of the reinforcement wires are fixed to an end of core 5. In the subsequent run of carriage 4, the rotating core

5 draws and winds the reinforcement wires from the reels 6 around itself. Therefore, the translation movement of carriage 4, combined with the rotation of the core 5 causes the wires to be arranged on the concrete layer previously laid, according to helixes whose pitch is determined by the ratios of the said speeds. Simultaneously to the winding of wires, the control and projecting unit 3 lays a layer above the applied reinforcement wires; in this way, on completion of the carriage's run, an increase of thickness is obtained in the tubular member on the core in whose thickness the reinforcement wires are embodied. At the end of the run of the carriage (which is shown at 3′ schematically, in dotted lines), the movement of the carriage is inverted without shut down, and the process continues back and forward until the wall thickness for the manufactured tubular member is attained.

The following is a more detailed description of the equipment and devices which compose the above illustrated apparatus according to another aspect of the invention.

The controlling and projecting unit 3 comprises:

a) a hopper 7, mounted on carriage 4, containing the concrete. Its shape is that of a truncated cone, with the smaller basis turned downwards, where a conical body 8 is located, which presents a conical shape inverted in respect of the external hopper 7, in order to give the tank a cross-section annular form gradually narrowing towards the base; the conical body revolves around its own axis and is equipped with paddles placed on its surface in contact with the concrete, and arranged in such a way as to convey same towards an annular slot placed between the bases of hopper 7 and body 8. By adjusting the revolving speed of the body, the number, shape and arrangement of the paddles, a steady flow of concrete is obtained towards the base slots, in this way eliminating vibrators and similar equipment that might determine a selection of the material;

b) a rotating plate, placed in correspondence of the lower slot of hopper 7, capable of collecting the concrete and of letting it fall, in each run and through a special slit, on a feed belt below, in an exactly measured

c) a feed belt, equipped with guillotine levellers for a further adjustment of the flow, that conveys the material to the projecting device;

d) a projecting device, consisting essentially of a couple of rolls 9 and 10, rotating at a high speed, each one provided with its own driving equipment and with their own axes parallel to one another and parallel to the axis of the rotating core (at a suitable distance in order to ensure that the concrete projection reaches the core with the required kinetic energy). The said rolls 9 and 10, rotating essentially in peripheral contact with one another, and lined with a layer of elastomeric material (smooth or possibly provided with parallel or inclined grooves, or of any other shape, as desired), project the concrete (that is conveyed by the feed belt in the nip of the two rolls) on the surface of the rotating core. All the equipment described under a), b), c), d) is mounted on the carriage 4, which, as previously said, can longitudinally move back and forth and is parallel to the axis of the rotating core 5;

e) a reel-holding carriage, which includes a given number of reels, equal to the number of steel wires to be used (up to 20 or even more), and one or more combs that fix the distance in between them, which can be varied according to requirements. This carriage moves longitudinally with a back and forth movement parallel to the core axis and in the figure, for purposes of simplification, carriage 4 represents both the control and projecting unit 3 carriage, and the reel-holding carriage 6, but as previously said these carriages are conceptually and practically separable;

f) a system for the heating of the core (by steam or by hot water or by electric resistances) in the step of the pipe manufacturing to speed up the demoulding of the pipe;

g) cylindrical cores that are usually made of metal sheet suitably ribbed and stiffened, that may be realized according to the following constructional methods, for demoulding:

1) with retractable sectors;

2) in one single piece, able to be opened along one generatrix line, and equipped with mechanisms suitable for determining a "wrapping" through said generatrix line;

3) in one single piece, not to be opened, but shaped with a slight taper of the external surfaces (a few mm per metre of length), which, although negligeable as far as the use of the manufactured pipe is concerned, is sufficient to allow the extraction of the core by means of suitable extractors; in this case, the demoulding may be made easier also by placing a continuous liner, or a band of thermoplastic material, between the external surface and the first layer of the projected concrete.

The apparatus lends itself to a number of alternative embodiments, representative of which are the following.

As previously illustrated, the reel-holding carriage may form an integral part of the controlling and projecting unit; the reel-holding carriages may be more than one, in order that they may simultaneously wind more than one reinforcement wire arranged in a different way on the surface of the piece under construction; the reel-holding carriages may be replaced, in their back and forth movement, by wire-guide spools; in this case, the reel unit will be fixed, and in a position suitable for distributing the wires to the spools; also the concrete projecting carriages may be more than one in order to speed up the manufacturing process; the apparatus may envisage fixed carriages and mobile rotating cores performing a back and forth movement; the axis of the core may be placed vertically instead of horizontally; in this case, the back and forth movement of the carriages in respect of the core or viceversa will take place along vertical and not horizontal routes.

Through the use of one or more reel-holding carriages, the most different types of reinforcements can be realized, for example, of the types described hereunder:

1) One single helix reinforcement, with the desired inclination in respect of the axis of the pipe, inter-crossing the return helix formed by the same carriage, in order to form a reinforcement wire mesh; the inclination is properly fixed in such a way as to distribute, in the required proportions, the iron resistance parallel or orthogonal to the axis of the pipe.

2) A double symmetric helix reinforcement in which two carriages simultaneously move one in a direction (for example, from left to right) and the other in the opposite direction (for example from right to left); the purpose is to realize the reinforcement wire mesh mentioned under 1) within one single concrete layer.

3) A double asymmetric helix reinforcement, for better differentiating the resistance distribution both transversally and longitudinally: in this case a carriage, with a slow movement (usually moving at a speed equal to that of the concrete projecting carriage) will form a short pitch helix, while a second carriage, whose back and forth movement is essentially faster, will form an elongated helix; especially in this case (but obviously also in the previous cases), the diameter and the number of wires distributed by each carriage may be different from one another, each one fit for the specific role the reinforcements will play in the finished pipe.

4) A multiple helix reinforcement, however formed, realized by means of any number of carriages acting simultaneously, with movements independent from each other and properly coordinated, in order to realize wire reinforcements of a special type, or simply to realize more quickly the envisaged wire reinforcements, or to increase the distribution of the reinforcement wires in the concrete.

The use of the reel-holding carriages, as described above, obviously allows, by changing the speed of each carriage in respect of that of the projecting carriage, by changing the number of reels in each carriage, by changing the diametre of the wire of each reel; by changing the distance between wires by means of the spacing comb with which each carriage is equipped, to embed in concrete any amount of ferrous material, however arranged and distributed.

The steel wire used for the reinforcement is preferably, but not limited to, a bare steel wire and its diameter is not greater than 3 mm. This is a wire gauge quite unusual in manufacturing reinforced concrete structures compared with a lower limit of 5 mm conventionally used only for particular purposes. This fact alone makes the structures built according to the process of the present invention a completely new building material easily distinguishable from ordinary or prestressed reinforced concrete structures.

A further embodiment of the process consists in the use, in lieu of reels carrying one single wire, of reels carrying a bundle of very thin wires, or of reels carrying a metal network band also consisting of thin wires.

Once the manufacturing of the pipe is completed, it is quickly cured by exposure to steam; as a rule, the pipe with the core is conveyed to a special station and placed in a special box (or covered with a tarpaulin), into which steam is conveyed under controlled temperature and humidity conditions.

After about 4 hours of treatment, the pipe can be stripped from the core, the latter being thus available for immediate re-use for the manufacturing of another pipe, and this because, contrary to the other methods which require the opening of moulds, the cleaning of the connections of same, the assembling and fixing of the steel reinforcement and, hence, the re-use of moulds practically after no less than eight hours, in the case of the present invention, none of the above mentioned operations is needed.

The manufacturing process according to the present invention, in that it involves the presence of the core, also envisages the immission of steam into the core, since the time the pipe is being manufactured (heat can be replaced by hot water circulating in special pipes located inside the core to ensure that the quick curing of concrete may start, from the outer layers to the inner layers, already during the manufacturing period: this method allows to reduce the period of time the pipes are to be kept in the curing box, from about 4 hours, as mentioned before, to 1—2 hours (according to the thickness of the wall; the time interval between two successive re-uses of the same core is accordingly reduced to about 2 hours. Therefore, an equipped of three cores for each pipe diameter is sufficient to ensure the continuity of the pipe manufacturing cycle, all of the same diameter.

Through the process according to the present invention, a concrete tubular member with a distributed reinforcement is thus realized, having the following characteristics:

a) inner diameter equal to that of the core;

b) any length, limited only by the length of the core; to obtain a shorter length, it will thus be sufficient to limit to the selected length the run of the carriages that distributed both the concrete and the reinforcement wires;

c) ends shaped according to the most various requirements, among which the most important is that of the socket and spigot joint, universally adopted for the concrete pipes, owing to its characteristics that ensure an excellent performance and are economically valid. In the previous description, the process was set forth for the construction of a pipe with smooth ends (spigots), this for purposes of simplification; on the other hand, the spigot may be replaced, for instance, by a socket end, by placing on the core, in a suitable position, a metal ring (counter socket) reproducing the internal shape of the socket itself; as regards the manufacturing of the pipe, once the concrete and steel distribution on the cylindrical body of the pipe is completed, it will be sufficient to limit the back and forth movement of the carriages to the short distance corresponding to the socket, to realize in that zone, with a suitable number of runs, the thickening of reinforced concrete that forms the socket shaped end of the pipe. This modification allows to realize, without any changing of the process and of the equipment, double spigot pipes, or double socket pipes, or again spigot and socket pipes, male and female pipes, etc.;

d) any desired thickness, as determined by the thickness of each concrete layer and by the number of layers (both these factors being at the manufacturer's option) and limited, therefore, only by practical requirements in the use of pipes and by commercial requirements. On the other hand, the thickness of the wall need not be uniform throughout the length of the tubular element; in fact, it is possible to realize, using the same procedure as for the shaping of the socket, any thicknesses in any point of the wall of the pipe and, in particular, reinforcement bands (similar to the angles in the metal pipes) for specially stressed pipes, or bands with a greater thickness where to bore, without in no way prejudicing the resistance of the pipe, breathers, outlets, etc.;

e) reinforcements, whatever their size and distribution may be, provided that they are within the practical limits mentioned above;

f) special features: the manufacturing process according to the invention allows the use of throwaway cores, this being a modification that is particularly interesting when pipes are to be manufactured, which are destined for specific purposes, that require special characteristics of the inner surface (high chemical resistance, high abrasion resistance, etc.). It will be sufficient in this case to replace the core by a shaft equipped with suitable supports, to place on the supports the throwaway core (for example, a pipe made of plastics and resistant to chemicals and/or abrasion) and to build on it the concrete pipe to obtain the embedding of the plastic pipe in the concrete pipe, or, in other words, to obtain a concrete pipe with an inner surface made of plastic material. The same purpose can be obviously obtained by placing a pipe made of plastic material on the normal metal core, or by winding a plastic band round the core, or by fixing the plastic material on the core by means of provisional screws or hooks (if it is in a sheet form); also partial linings of the inner surface of the pipe can be thus obtained.

The same result (that of giving the pipe a particular chemical or mechanical resistance) can be obtained using the manufacturing process according to the present invention, by realizing "sandwich" structures, that is, by inserting concrete layers in between polymeric binding mortar layers: it will be sufficient: for this purpose, to have available a projecting unit fed with such mortars, without any further changes in the equipment and without any modifications in the process; the special layer (layers) can be obviously arranged at will, either on the inner surface, or on the outer surface, or within the thicknesses, according to its (their) purpose. Nothing of the kind is possible when the known methods for manufacturing concrete pipes are used. If one wishes to protect, in particular, the reinforcement wires, it will be also possible to place after each comb, a bath consisting of a special material, to ensure that the wires reach the surface of the pipe impregnated with the protective substance; using the same process, the wires can be impregnated with the known adhesive substances, which enhance both the adhesion and the bond between concrete and reinforcement steel.

Moreover, the reinforcement wires can be replaced by fiber glass resistant to alkalis, when the products to be manufactured are destined for the transportation of fluids particularly damaging for steel, or must be installed in areas where aggresive conditions are detected.

The versatility of the method obviously allows the use of all kinds of concrete additives (accelerators, water-proofing materials, expansion materials, etc.); of special interest is the use of the expansion materials, whose effect is enhanced by the evenly distributed reinforcement, and from the use of which remarkable increases can be expected in concrete resistance.

In view of the fact that the cement used for the manufacturing of the pipe is not subject to any action that may cause selective effects (vibration, centrifugation, etc.), the process according to the present invention allows the use of light aggregates or of mixed aggregates (both light and heavy aggregates), in those cases in which the weight of the manufactured products is to be kept within given limits.

From the previous description, the following advantages clearly emerge of the manufacturing process according to the present invention:

1) an exceedingly great versatility, for what concerns the shape, size and resistance of the manufactured product; the remarkable simplicity of the equipment used and of the manufacturing method. It is to be observed, in particular, that the process described here, unlike any other process known so far, allows to simultaneously perform the operations for the construction of the wall of the pipe, the compacting thereof, the formation and embedding of the reinforcement, the quickened initial curing; with the prior art methods, on the contrary, all these operations took place in successive steps and, mostly, in different working stations and with separate machines;

2) notable hydraulic characteristics of the manufactured product; the inner surface projected against the metal core actually is perfectly smooth and presents an extremely low coefficient of roughness, by far lower than that of the pipes manufactured according to other industrially widespread methods (centrifugation, rolling, etc.), only comparable with that of pipes vertically cast between two concentric moulds (a method, this one, that for economic reasons is only used today for the manufacturing of large diametre pipes).

3) outstanding mechanical characteristics of the manufactured product; it is a well-known fact that the use of concrete is essentially based on the bond of two materials: concrete and steel, and that the greater the contact surface they have in common, the more effective is this bond; only a number of reasons of a practical and economic nature presently restrain the exploitation of this bond, imposing the use of reinforcements consisting of irons with a comparatively large diametre; the practical use of a widely extended and homogeneously distributed reinforcement represents therefore an excellent result from the point of view of the construction theory and guarantees the obtainment of extremely high mechanical resistances of the whole. In particular, for structures subjected to high stresses, such as the pipes destined for pressure conduits, the evenly distributed reinforcement offsets the negative effects of shrinkage, also with high cement content, and prevents the formation of the relevant fissures that, in the presently manufactured pipes, represent a dangerous starting point for subsequent cracks.

Therefore, the product manufactured according to the present invention represents an entirely new industrial product, when compared with the pipes presently in existence, made of either reinforced concrete or prestressed reinforced concrete.

In fact, the pipes manufactured according to the process according to the invention, allow to fully realize concrete pipelines with one single type of manufactured product, and this ensures a similar behaviour on the part of all the elements as far as the strains acting on them are concerned; this is particularly important in regard of the margin of safety in case of cracks. The concrete pipelines, as they are now realized, present, instead, a truly irrational situation in this connection, when they are made — as it is the case for the great majority of them — of reinforced concrete pipes (that, using the mere tensile strength of reinforced concrete, result very weak as far as the external stresses are concerned and afford very reduced margins of safety in case of cracks) or of prestressed reinforced concrete pipes (whose margins of safety in case of cracks are by far greater).

Since the resistance of a group of different elements is to be evidently compared with the resistance of its weakest element, there ensues that the present mixed pipelines afford very reduced margins of safety, such as those of the reinforced concrete pipes, while the margin for the prestressed concrete pipes is practically inoperative.

The new type of pipe affords the highest possible saving in raw materials; it is in fact possible to accurately adjust both thicknesses and reinforcements to the required pressure, that which is not practically possible with the pipes presently commercially available.

Also the possibility of varying, to a very large extent, the magnitude of the embedded reinforcement, its distribution, its inclination in respect of the axis, etc., allows to exactly adapt the manufactured products to the required working conditions; nothing of the kind is possible with regard to the presently manufactured pipes, in which a very rigid approach in matter of reinforcement is imposed by technological reasons.

In addition to their very high versatility in regard of strains, the pipes under consideration present an outstanding resistance as a result of the evenly distributed reinforcements; a pipe of the type under examination — the thickness and steel weight being equal — is by far more resistant (twice as resistant at least) than a conventional reinforced concrete pipe on the market.

At any rate, even in the event that exceptional causes should determine the formation of a fissure, it will immediately tend to close up as soon as the cause that determined it has disappeared: this phenomenon, whereby all accidental fissures in concrete with evenly distributed reinforcement tend to close up, is well known and was repeatedly observed on all the structures of this type. Nothing of the kind can be expected from reinforced concrete pipes presently manufactured.

In the prior art pipelines of a considerable economic weight are the special fittings (breathers, outlets, derivations, etc.) and the protection structures (in correspondence of road or railway crossings, of other ducts, under exceptionally high embankments, etc.); in the case of the pipes of the type according to the invention the possibility of creating strengthenings on the external surface (for realizing breathers, outlets, etc., and for equipping the pipes with stiffening angles) and the absence of prestress steel (that would be cut) will allow to eliminate most of the special fittings and of the protection structures, with an evident economic advantage.

As regards the cost of the special fittings, a further saving may result from the possibility of producing any type of pipes with spigot or socket ends or with any other type of ends, without any increases in costs, and also from the possibility of manufacturing pipes of a length inferior to the standard one.

Although the new pipes can be utilized in the field presently occupied by the prestressed pipes, they do not require the use of high tensile steel, whose high susceptibility to corrosion is well known; their use will involve no risks, as far as corrosion is concened, and none of the measures presently adopted for prestressed pipes (concrete and bituminous linings, cathodic protection) will be necessary.

The use or throwaway cores, of materials resistant to chemical agents or to abrasion, allows to adapt the pipes, according to the present invention, to the conveyance of any type of fluids, without any complication in the manufacturing operation and without any additional work; to obtain the same results with the pipes presently available on the market, expensive and toilsome additions of protective layers (stoneware tiles, varnishes or mortars in plastic compounds, etc.), are required.

The process of the present invention envisages, as an alternative to the use of throwaway cores, the formation of the inner layer of the pipes using resin mortar, which is not subject to acid corrosion, and then the formation of the rest of the wall using standard concrete.

The process further envisages the possibility of using light or heavy aggregates, or mixed aggregates realizing "sandwich" structures with polymeric resins; of protecting the reinforcement wires by impregnating them with those same resins, in such a way as to extend the scope of application of the new pipes to cover the transportation of any kind of fluids, and the laying of pipes in aggresive environments. All this can be done without in any way altering the constructional procedure, and hence with no additional costs (other than those referring to the material used). The pipes that are manufactured today afford no possibilities of the kind, as everyone knows, and so their scope of application is narrower, all the more so if one considers that, for these special cases, one must resort to more expensive pipelines (stonework, reinforced plastic materials, etc.).

The process further envisages the possibility of creating a thin layer of resin within the wall of the pipe, with the twofold function of impermeabilizing and protecting iron.

The possibility also exists of passing the reinforcing wires through a resin bath (for example epoxy resins), in order to increase the bond between iron and concrete, and, hence, the resistance of the pipe.

The process also allows to use alkali-resistant fibreglass, as reinforcers, in lieu of steel wires, with all the ensuing advantages.

The present invention is not limited to the manufacturing of pipes for the transportation of fluids, but it is also effective for the manufacturing of pillars, poles for electric lines or foundations, columns, beams or hollow piles and similar having a cylindrical or polygonal or polycentric cross-section, depending only of the cross-section of the core employed.

Examples.

Test pipes were manufactured from a concrete mixture with an aggregate particle size lower than 3 mm and having the following resistance features at 28 days:

pure tensile strength 65 kg/sq cm
tensile bending strength 100 kg/sq cm
compression strength 700 kg/sq cm

Steel wires with a diameter of 0.8 mm and 1 mm and an ultimate tensile strength higher than 80 kg/sq mm were used for the reinforcement.

The pipes were 2 to 5 meters long, the inner diameters thereof were 500 mm and 800 mm, with different thickness varying within a wide range. The volume ratio and the arrangement of the reinforcement wire was also varied to test the effect thereof on the pipe resistance.

The manufactured pipes had an exceedingly high smoothness and compactness of their inner surface and a very high accuracy of size and shape.

Tensile stress tests.

From said pipes, cylindrical specimens (cores) were cut by grinding and were tested for ultimate tensile strength; the strain (deformation) was measured by electrical straingauges.

The tests carried out on the cylindrical speciments have shown that the ultimate tensile strength (U.T.S.) depends on the volume ratio (V.R.) of the distributed reinforcement wire lying in the direction of stress.

The following average values have been measured for the above cylindrical specimens.

V.R.	U.T.S.
2.0%	110 kg/sq cm
2.5%	125—130 kg/sq cm

For higher reinforcement ratios it was difficult to cut cylindrical specimens due to the thinness of the pipe wall, whereupon annular specimens have been cut by grinding from pipes of 500 mm inner diameter. Said specimens were 20 cm long.

A testing apparatus was set up with a metal pipe of 400 mm outer diameter, 20 cm long, provided with removable end flanges and a rubber thoroidal bag which could be inflated by water under pressure.

The pipe section to be tested was placed between the metal flanges with a clearance of about 1 mm apart from said flanges, so as not to be stressed by them. A thoroidal room was thus formed between the 500 mm pipe section to be tested, the 400 mm metal pipe section and both flanges. The rubber bag was placed into said room. When put under pressure it stressed the concrete pipe section by a tensile load.

In said apparatus a plurality of reinforced concrete annular specimens according to the invention were tested for the ultimate tensile strength (U.T.S.) with different volume ratios (V.R.) of reinforcement in the direction of stress. The average results were as follows:

V.R. (%)	U.T.S. (kg/sq cm)
2.5	100—115
4.0	115—130
5.0	125—140

Observations by means of the electrical straingauges have shown that the breakage of the specimens under tensile stress was preceded by a plurality of microcracks which otherwise were confined and stopped by the metal elements of the reinforcement. Such an effect, which is known and peculiar to reinforced concrete with an evenly distributed reinforcement, is particularly interesting in the field of pipes.

Inner pressure tests.

The above illustrated pipes were subjected to inner pressure and tested to breakage. Said tests confirmed the results for the tensile stress tests carried out on the above cylindrical and annular specimens. The average results and indications of the tests are listed in the following table 1.

TABLE 1

Results of inner pressure tests

Pipe diameter (mm)	Piper thickness (cm)	Reinforcement (kg/linear meter)	Breakage pressure (atmospheres)
500	5	17	16–17
500	7	34	28–30
800	6	38	13.5–15
800	8	60	21–23

It is to be noted that since about on-third of the reinforcement wire was placed slantwise to the centre line of the pipe to take the beam stress (longitudinal bending stress), only the remaining two-thirds of the reinforcement wire has to be considered as useful for taking the inner pressure. Therefore, from the results of table 1 the following average values for the ultimate tensile strength in the test conditions, can be calculated:

V.R. (%)	U.T.S. (kg/sq cm)
2.5	80
3.0	90
3.5	100

As to the breaking pattern it was observed that the pipes maintained their sealing ability until the actual breakage occurred. Breakage occurred in the form of a plurality of close packed cracks lying in the longitudinal direction of the pipe, having a very reduced length of a few centimeters, each one apart from the other. Due to the small size of said cracks, the loss of water was reduced and a water tight seal was formed again in a short time (few hours) as a result of hydration of the concrete coming in contact with water, so that the pipes became perfectly water tight even at the pressure which produced the first cracks.

The above procedure could be repeated several times at increasing pressures, until longitudinal cracks were produced coextensive to the whole length of the pipe, at which time a sealing could no more be obtained.

The tests have shown that one could rely on a 30% margin from the pressure at which the first cracks occurred to the ultimate collapse pressure.

The test results show that the pipes according to the invention, their diameter, thickness and reinforcement ratio being equal, have a far superior resistance than conventional reinforced concrete pipes, so that they are able to be advantageously used in lieu of both ordinary reinforced concrete pipes (in a pressure range from 1 to 6 atmospheres) and prestressed reinforced concrete pipes (in a pressure range from 6 to 20 atmospheres).

WHAT WE CLAIM IS:—

1. A process for manufacturing a tubular member consisting of a wall of projected concrete, strengthened with a continuous evenly distributed reinforcement, in any desired thickness, which process includes the operations of preparing a concrete mixture with such a water-cement ratio as to present a characteristic substantially of slump zero; adjusting the flow rate of the said concrete mixture in order to obtain an essentially steady flow rate; projecting said concrete mixture continuously and in a steady flow rate, in the form of a thin laminar jet of a substantially uniform width, at a high impact speed, on the external surface of a first preset concrete tubular layer projected on a tubular core rotating around its axis; causing the point of impact of the said jet against the surface of the first tubular layer to move along the longitudinal axis of the tubular core, while applying on the surface of the first tubular layer, simultaneously with the said projecting operation, at a point constantly ahead of the point of impact of the jet, an helicoidal continuous winding of reinforcement wire, in such a way that the said projected concrete produces a self-supporting concrete layer, which covers and embeds the said reinforcement wire winding and which adheres to the said first tubular layer; repeating in the opposite direction and with continuity, the said operations of wire winding and of concrete projecting, every time that the jet reaches an end of the tubular core, until the wall of the tubular member has the desired thickness, this wall being thus made of a monolithic concrete mix embedding a set of concentric, co-axial, helicoidal windings of continuous metal wire.

2. A process as claimed in Claim 1, in which the said laminar jet has a thickness of a few mm, a width of some cm, and its speed, at the point of impact, is not lower than 60 km/h.

3. A process as claimed in either Claim 1 or 2, in which the end of the reinforcement wire is fixed to the first tubular layer, and the application of the winding takes place automatically, by unwinding the wire from a reel and letting it wind around the rotating tubular layer, while the reel is caused to move in the direction of the longitudinal axis of the said tubular core.

4. A process according to any of the preceding claims, in which the said reinforcement wire is made of steel of a diameter not exceeding 3 mm.

5. A process according to any of the preceding claims, in which, when the point of impact of the jet is caused to move along the longitudinal axis of the tubular core, a plurality of sets of helicoidal winding is applied, each set consisting of a continuous reinforcement wire.

6. A process as claimed in Claim 5, in which the reels from which the said wires are unwound, may move at different traverse speeds along the longitudinal axis of the tubular core, and may also move in both directions.

7. A process according to any one of the preceding claims, in which at least some of the said reinforcement wires may consist in a mesh of very thin wires or of a band of metal network.

8. A process according to any one of the preceding claims, including also the operation of heating the tubular member during the projecting of concrete, in order to hasten its curing.

9. A process as claimed in Claim 8, in which the heating of the tubular member takes place by means of the immission of steam within the tubular core.

10. A process as claimed in Claim 8, in which the tubular member is formed by projecting pre-heated concrete.

11. A process according to any one of the preceding claims, in which, at the beginning of the process, the concrete jet is projected on a recoverable core, to form the said first layer of the tubular member.

12. A process of any one of the Claims 1 to 10, in which, at the beginning of the process, the concrete jet is projected on a throw-away core, to form the said first layer of the tubular member.

13. A process according to any one of the preceding claims, in which the composition of the concrete mix may be different for the different layers projected on the wall of the tubular member.

14. A process as claimed in Claim 13, in which the concrete mix further contains polymeric resin additives, for the formation of layers, either impermeable or resistant to chemical agents.

15. A process according to any one of the preceding claims, in which the reinforcement wire is lined with resins capable of enhancing its bond with concrete.

16. A process according to any one of the preceding claims, in which the wall thickness of the tubular member being manufactured, is increased, in given points of the said tubular element, in respect of the rest of same, by

applying only on those points some extra layers of concrete and reinforcement wire.

17. An apparatus for carrying out the process of any one of claims 1 to 16, comprising a station for the batching and mixing of the concrete components for making the mixture; facilities for the transportation of the mix; a unit for projecting the concrete, movable with a back and forth movement, and a core rotating around its longitudinal axis, placed with said axis parallel to the direction of the back and forth movement of said projecting unit, at such a distance as to receive on the surface the concrete jet projected by said unit; one or more reels of distributing the reinforcement wire, said wire being fed with a traverse movement to said core and wound in an helicoidal pattern around the axis of said core; said apparatus being characterized by the fact that the concrete projecting unit includes a device for controlling the concrete flow rate, which steadily feeds a projecting unit consisting of a pair of rolls rotating at a high speed, placed on axes parallel to one another and parallel to the axis of the core, said rolls rotating at a peripheral contact with each other and being made of or lined with an elastomeric material, in such a way as to project a steady laminar concrete jet with a high kinetic energy on said core.

18. Apparatus as claimed in Claim 17, in which the device for the control of the concrete flow rate includes a hopper shaped like a truncated cone with the smaller basis turned downwards, which presents a conical body with an inverted conical shape; said conical-shaped body rotating around its own axis and being equipped with directing paddles fit for conveying the concrete towards the annular slot formed by the internal wall of the hopper and by the external wall of the conical body; a rotating plate, placed below said slot, capable of collecting the concrete and of distributing, in each run, an exactly measured amount; a feed belt, which receives the said measured amount from the rotating plate, which conveys the material to the projecting unit.

19. Apparatus as claimed in Claim 17, in which each of the said rolls of the projecting unit is driven by its own motor.

20. Apparatus as claimed in any one of Claims 17 to 19, in which the projecting unit and the rate control device are mounted on a carriage movable on wheels.

21. Apparatus as claimed in Claim 17, in which said reel or reels for the distribution of reinforcement wire are mounted on various carriages for performing the said traverse movement independently one to another.

22. Apparatus as claimed in Claims 17 and 20, in which the said reel or reels are mounted on the same carriage of the rate control device and projecting unit, so as to perform said traverse movement concurrently with the back and forth movement of said carriage.

23. Apparatus as claimed in Claims 21 and 22, in which each reel-carrying carriage includes a number of reels equal to the number of the steel wires that one intends to use, and one or more combs that fix the spacing of these wires.

24. Apparatus according to Claim 17, in which the said traverse movement of the reinforcement wire, takes place by means of guide-wire spools with a back and forth movement, whilst the reel or reels is or are fixed in respect of the core.

25. Apparatus according to Claim 17, in which the back and forth movement between the unit for the projecting of concrete and said core takes place as a result of a back and forth translation movement of said unit in respect of a fixed core, or vice versa.

26. Apparatus according to any one of the preceding Claims 17 to 25, in which said rotating core is placed with its axis in a fixed horizontal position, and the back and forth movement of the carriage or carriages in respect of the core takes place along horizontal routes.

27. Apparatus according to any one of the preceding claims, further including a plant for the production of steam or of heat for the quick curing of concrete during and/or after the manufacturing of the tubular member.

28. Apparatus according to any one of the preceding claims, including a core of one single diameter size for the manufacturing of tubular members of one single inner diameter and different outer diameters.

29. Apparatus according to any one of the preceding claims, including a core of one single length, for the formation of tubular members of different lengths, provided that such lengths are less than to the length of the core.

30. Apparatus according to any one of the preceding claims, further including metal rings reproducing the internal shape of a shaped end of the tubular member, said metal rings being able to be fitted on said smooth core, in any position, to form a tubular member provided with internally shaped ends.

31. Tubular member made of reinforced concrete and produced by the process of any one of Claims 1 to 16, consisting of a wall of projected concrete mix, in which a reinforcement is finely and evenly distributed, which is formed by a set of concentric helicoidal windings made of one single continuous metal wire.

32. Tubular member as claimed in Claim 31, in which the distributed reinforcement is formed by a plurality of sets of co-axial concentric helicoidal windings, each set consisting of one single continuous metal wire.

33. Tubular member as claimed in Claim

32, in which said plurality of sets of helicoidal windings have a helix pitch different from one another.

34. Tubular member as claimed in any one of the Claims 31 to 33, in which the said metal wire is a steel wire with a diameter inferior to 3 mm.

35. Tubular member as claimed in Claim 34, in which the said steel wire is a bare steel wire.

36. Tubular member as claimed in any one of Claims 31 to 35, whose wall has an increased integral thickness in given points of the said tubular member.

37. Tubular member as claimed in any one of Claims 31 to 36, whose wall includes inner and/or outer and/or intermediate layers of waterproofing materials, resistant to chemical agents or to abrasion.

38. Tubular member as claimed in any one of Claims 31 to 37, in which the said reinforcement wires are lined with resins suitable for increasing the bond between iron and cement.

39. Tubular member as claimed in any one of Claims 31 to 38, which comprises a pipe for conduits for the conveyance of fluids.

40. Tubular member as claimed in Claim 39, which comprises a pipe which can be used — its size being substantially equal to that of a prestressed reinforced-concrete pipe — in conduits with a range of working pressures higher than that of a conventional reinforced-concrete pipe can bear.

41. Tubular member as claimed in either of Claims 39 and 40, in which the said pipe is provided with joining shaped ends, integral with the pipe.

42. Tubular member as claimed in Claim 41, in which the said joining shaped ends consist of collar or socket and spigot joints.

43. Tubular member as claimed in any one of Claims 31 to 38, having a circular or polycentric or polygonal cross-section, which comprises a pipe for electric lines or for foun dations, or a pillar or column, or a beam.

44. A process for manufacturing a tubular member substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

45. Apparatus for the manufacture of a tubular member substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

46. A tubular member substantially as hereinbefore described.

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