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(54) **Concrete reinforcing steel bars provided with bituminous protective means against oxidation, and treatment method therefor**

Betonstahl mit Bitumenschutzmitteln gegen Oxidation, und Behandlungsverfahren dafür

Barres d'armature pour béton pourvues de moyens de protection en bitume contre l'oxydation et méthode de traitement s'y rapportant

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(73) Proprietor: **Santonocito, Antonino**
95040 Motta S. Anastasia (CT) (IT)

(72) Inventor: **Santonocito, Antonino**
95040 Motta S. Anastasia (CT) (IT)

(74) Representative: **Sarpi, Maurizio et al**
Studio Ferrario S.r.l.
Via Collina, 36
00187 Roma (IT)

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Description

[0001] The present invention regards steel bars provided with an anti-oxidizing protective means of a bituminous type and the corresponding industrial production process.

[0002] Steel is a material very widely used in the building industry, preferred for its particular characteristics and mechanical performance.

[0003] The main use of steel in the building sector is for steel structural work and reinforcements, the latter being preferred in more traditional techniques, where they constitute the skeleton resistant to the stresses of bending and shear of reinforced concrete.

[0004] The basic disadvantage presented by steels is the fact that, even though they are iron-carbon alloys and not simply iron (even though in the current Italian jargon the operators of the sector call it "iron"), are subject to degradation due to corrosion of the iron present in the alloy, an inevitable oxidative process for all types of steel different from stainless ones (which in any case have a cost by far superior to traditional steels), caused by a spontaneous and irreversible phenomenon triggered by the chemico-physical interaction with the environment where they are stored.

[0005] The most common corrosive agents are oxygen and water, even though it is commonly said that the metal rusts, flaking continuously: the rust, namely, the layer of steel and hence of iron that oxidizes, penetrates over time more and more deeply into the metal sections, up to total loss of the characteristics of resistance of the constructional element, or even up to its total destruction.

[0006] Usually, corrosion in building structures manifests itself via splitting of the reinforced-concrete surfaces that is increasingly visible over time, which may be found not only on large infrastructures such as bridges, but also in the more exposed parts of buildings.

[0007] Theoretically, said corrosive phenomenon should not occur in so far as concrete usually constitutes a reducing and non-oxidizing alkaline environment, hence protecting the metal bars themselves. In actual fact, the alkalinity of the environment surrounding the reinforcements decreases over time until it disappears totally on account of the entry of aggressive substances, such as carbon dioxide, sulphur dioxide, and chlorides.

[0008] Said contradiction between theory and practice is due to the fact that the theory hypothesizes the cementitious matrix as being impenetrable by the acidifying agents referred to above, but concretes produced on building sites are not always perfectly similar to laboratory specimens, and, even though they respect given values of the ratio between water, cement, and volume of air englobed in the mix, the cementitious matrix presents in any case a given level of porosity that justifies said penetration of acids, which causes degradation of the rods and of the concrete itself. The part of iron that oxidizes, in fact, converting into rust, presents the characteristic of expanding in volume, causing the initial splits in the concrete cover, above all in those cases (unfortunately very frequent) in which it has an inadequate thickness. The process thus triggered of decay of the product is irreversible, until intervention with works of cleaning, protection, and restoration of the entire damaged part is made.

[0009] It is not, however, necessary for the metal object to be macroscopically involved by corrosion for its technological decay to come about. In fact, another disadvantage of corrosion of steels is inherent in the reduction of the functional efficiency due to corrosion, which can occur only for specific resistant sections, where there may even be the maximum mechanical stresses of the building structure.

[0010] The process of corrosion in dry environments is basically due to chemical reactions with oxidizing gases. The phenomenon consists in the tendency to restore the oxidized form, which is the one in which the metals are of course stable. It envisages combination with the oxygen present in the atmosphere to form the corresponding oxide, or else with other atmospheric agents to form carbonates, sulphates, hydroxides, and sulphides. In damp environments, instead, corrosion occurs thanks to electrochemical reactions. These reactions are linked to the passage of electric current in the solutions. When two different metals are dipped in water or merely in the ground, which is always assumed to be at least damp, a difference of potential is generated between them, and if there is union through a conductive element between them, this will be traversed by electric current, since the more reactive metal tends to oxidize as occurs in a battery cell. If, for example, the steel in question is in contact with another less reactive metal, or else characterized by a lack of homogeneity of composition, it will be in danger of corrosion. The corrosive phenomenon so far described occurs, obviously, if the metal is "bare", i.e., without any protection. To prevent, in fact, degradation of steel structures, it is necessary to coat the cementitious products with adequate barriers that insulate the metal from the corrosive agents of the external environment.

[0011] Protection of the metal surfaces, in particular the bars, as is technically known today, is obtained with the application of antioxidant paint (rust-resistant paint), with the application of sacrificial anodes and protective coatings of the steel bars themselves with non-ferrous metals.

[0012] The use of said coatings is always necessary in so far as the metal material by far most widely used in the residential sector is low-alloy steel, which is markedly affected by attack from rust, but the disadvantages in this case are correlated to the excessive cost due to the application of said protective coating.

[0013] To be able to prolong the duration over time of the products of steel structural work there is first of all necessary a correct prevention, to be envisaged right from the design stage, given that it must depend strictly upon the environmental conditions of operation of the structure itself. In addition, as long as the latter is in service, essential for the purposes of service life is the frequency and quality of the maintenance interventions, even though these present the further disadvantage of representing a non-indifferent periodic cost.

[0014] Maintenance is thus an important stage in the life of a metal product or a product made of reinforced concrete and must be timely, carried out with modalities adapted to the environmental needs, and to the extent where it is feasible taking into account the costs involved.

[0015] A further disadvantage, in fact, lies in the cost of the surface coatings that can be used, but even more in the manpower required both for the necessary operations of cleaning of the rusted parts (sandblasting in the case of structures that cannot be taken down, scraping using a steel brush, if the parts to be removed are of small size) and for the subsequent painting cycle, from the first layer of rust-resistant undercoat, also referred to as "primer", to be applied with a paintbrush, roller, or airless spray, in order to prevent any further undesirable oxidation of the metal, to the subsequent coats of paint with passivating pigments (necessary for obtaining a thin passive layer on steel in order to block oxidation thereof and reaction with the possible aggressive substances that can penetrate through the overlying layers of paint, forming insoluble compounds that are not aggressive for the material to be protected).

[0016] Another disadvantage of no less importance as compared to the previous ones is linked precisely to the cost of said paint with anti-oxidizing pigment (with a base of epoxy polyamide having a high content of metallic zinc or with a base of chromates, metaborates, or phosphates, such as zinc phosphate), for which the choice cannot be underestimated and must always be oriented towards the qualitatively better products that have optimal adhesion to the metal substrate and good anchorage to the next layer of paint.

[0017] Even the least expensive solution regarding the case where it is preferred to save on manpower for cleaning and preparation of the surfaces, opting for carrying out a rough removal of the rust from the metal bars, presents the disadvantage of requiring, for the protection of the metal surfaces, the use of costly rust-converting or rust-stabilizing primers, based upon solutions of sulphuric acid or tannins with or without sulphuric acid, associated to which is the further cost of universal primers, which are in turn made up of phenolic resins modified with alkyl resins, compatible with all paints, always with the purpose of obtaining the effect of barrier in regard to water vapour, oxygen, and aggressive and corrosive substances in so far as the primer alone does not in general present impermeable properties.

[0018] It must likewise be borne in mind that to said costly operations of maintenance there must be added the costs due to the prior dismantling and gathering of the concrete cover and transportation thereof to dumps, as likewise the subsequent replacement thereof.

[0019] A further procedure for protecting the metal surfaces of steel bars, or metal bars in general, is represented by coating paints with a base of bitumens, of bituminous combinations, ofepoxyorepoxypolyurethane, of alkyl resins, of chlorinated rubber, and finally of a combination of PVC and acrylic resins, but for all these solutions the disadvantage of the cost of manpower is always present, and is comparable with, if not almost always higher than, the costs of the products to be applied themselves.

[0020] Likewise known to the art are universal coatings for steel that do not require application of the primer and are particularly indicated for painting over old coatings, but for these universal coatings the disadvantages are correlated both to the cost of manpower and to the cost of the product to be applied.

[0021] One of the protection procedures currently most widespread is hot-dip galvanizing in so far as it represents a coating that responds in quite an effective and durable way over time in so far as it protects steel in a dual way -both physically and electrochemically - even though today it appears less and less economically advantageous as applicational solution. Hot-dip galvanizing, in fact, is an industrial process that guarantees the physical protection of the steel coated by the surface layer of zinc that isolates it materially from the surrounding environment, whilst the electrochemical protection is triggered by the higher electronegativity of zinc as compared to steel. There is in fact formed a Zn-Fe cell so that the zinc is sacrificed to protect the iron above all in the accidentally damaged areas (also referred to as "cathodic protection").

[0022] The disadvantage of the latter protection procedure is, however, inherent in its poor reliability, given that it is always necessary to test the galvanizing operation itself properly since an insufficient zinc coating on the metal surfaces can jeopardize the duration of the coating itself, which is a function of the thickness of zinc applied and of the type of environment to which the product will be exposed, factors that determine the rate of corrosion of the coating.

[0023] Corrosion of the layer of zinc, in fact, usually takes place above all in the first period of life of the concrete product, when the degree of alkalinity within it is still very high in so far as zinc, unlike iron, oxidizes in this type of environment, even though, in any case, the use of galvanized bars provides a non-negligible increase in durability of the reinforced concrete itself, since zinc, by corroding, performs its protective function in regard to the underlying steel. Since the products of corrosion of the zinc, in fact, do not expand as occurs in the case of rust, they do not cause mechanical damage to the surrounding concrete. Corrosion of zinc is the sign in any case of a cathodic protection on steel, which, however, as a result, progressively loses its coating. It is only upon expiry of the period of protection due to the disappearance of the protective layer of zinc that steel starts to corrode like traditional reinforcements, even though the increase in service life of the cementitious structures themselves is evident.

[0024] A further disadvantage of said hot-dip galvanizing process is represented by the fact that it cannot be applied on metal reinforcements of building products that have already been installed, but that require maintenance, where at most it is possible to resort to cold galvanizing, but this latter treatment is even less effective and durable than the previous one.

[0025] Since corrosion of the reinforcements within the conglomerates can thus occur also in the case of well prepared cementitious mixes, even though it develops more slowly over time, at times it leads to the more drastic decision of replacing the traditional reinforcements with other types of less reactive materials, such as, for example, stainless steel, titanium, or even composite fibres, but the disadvantage of said solutions is obviously linked to the much higher costs.

[0026] A further technically known solution has been that of coating traditional steel bars with corrosion-resistant materials, such as, for example, epoxy resins. The application of these, however, presents disadvantages regarding storage of the bars themselves prior to use and handling thereof when they are being laid, as likewise the less-than-perfect adhesion of the coated surfaces to the concrete.

[0027] The document DD 101 198 A1 discloses a metal bar having all the features of the preamble of claim 1 and a process for the treatment of metal bars having all the features of the preamble of claim 2.

[0028] The main purpose of the present invention is consequently to provide at an industrial level, via a production process that is simple to implement at a minimum production cost, steel bars provided with a valid anti-oxidizing protective means.

[0029] A further purpose of the present invention, which is no less important than the previous one, is to obtain steel bars that can be stored without undergoing oxidation even if they are left out in the open for prolonged periods of time, without any problems connected to their handling and to the necessary operations of bending and shearing, and that can at any moment be used without the need to perform undesirable treatments of brushing of the oxidative surface layer that normally forms on customary steel bars when, after being produced by wire drawing, are stored, even for a short time.

[0030] Another purpose of the present invention is to provide steel bars that will guarantee a centuries-long resistance of the products made of reinforced concrete built using them, thus preventing the undesirable phenomena of hidden or evident oxidation of the steel with the corresponding impoverishment of the characteristics of resistance both of the steel bars and of the reinforced concrete that coats them.

[0031] The above purposes are achieved by providing metal bars of any class and diameter for use in the building sector for steel structural work or for reinforcements, according to claim 1, and by providing a process for the treatment of metal bars according to claim 2.

[0032] The present invention and the corresponding production process are altogether innovative in so far as there do not so far exist steel bars of similar conformation and characteristics and are inventive because they altogether solve the problem that has so far remained unresolved regarding corrosion of steel especially when it is present as reinforcement in buildings made of reinforced concrete.

[0033] The above purposes and the consequent advantages, as well as the characteristics of the invention and of the corresponding production process according to the present invention, will emerge more clearly from the ensuing detailed description of some preferred solutions, which are provided by way of non-limiting example, with reference to the attached drawings, and in which:

- **Figure 1** is an overall schematic view of the set of three steps F_1-F_2-F_3, where the dashed arrows indicate the sequence of said steps making up the industrial process P for production of the bars B provided with anti-oxidizing protective means according to the present invention, up to their transportation on articulated lorries T;
- **Figure 2** is a schematic top plan view of just the impregnation step F_1, represented in Figure 1, in which there appears a plurality of steel bars B_0 entering the impregnation tank V_1 and, following upon impregnation, the same bars impregnated with bituminous solution B_1 at output; the arrows parallel to the bars B_0-B_1 indicate the orientation of movement of the bars B_0-B_1 themselves, whilst the small arrows oriented downwards and upwards indicate, respectively, the thermal range ΔT_1 and the time interval of impregnation Δt_1;
- **Figure 3** is a schematic top plan view of just the emulsion-treatment step F_2, represented in Figure 1, in which there appears a plurality of steel bars B_1 entering the emulsion tank V_2 and, following upon the treatment with the emulsion, the same bars impregnated and treated with the bituminous emulsion B_2 at output; the arrows parallel to the bars B_1-B_2 indicate the orientation of movement of the bars B_1-B_2 themselves, whilst the small arrows oriented downwards and upwards indicate, respectively, the thermal range ΔT_2 and the emulsion time Δt_2;
- **Figure 4** is an illustration of a traditional steel bar, in particular a reinforcing rod B_0;
- **Figure 5** is an illustration of a bar B_1 impregnated with the cold bituminous solution S_b;
- **Figure 6** is an illustration of a bar B_2 treated with the hot bituminous emulsion E_b; and
- **Figure 7** is an illustration of a bar B, already dried, in rectilinear configuration and bent at 90°, ready for use.

[0034] From the attached figures, it emerges that the metal bars B, of any class and diameter for use in the building sector for steel structural work or for reinforcements, according to the present invention are basically **characterized in that** they have undergone an industrial production process P that envisages treatment with anti-oxidizing protective means of a bituminous type S_b-E_b, compatible in an optimal way also with any type of concrete, for building structures with and without reinforced concrete that are unattackable by corrosion and hence durable over time.

[0035] According to the invention, the industrial production process P is obtained via the application of a series of steps, as emerges readily from Figures 1, 2 and 3, respectively of impregnation F_1, emulsion treatment F_2, and drying F_3, said steps being performed in temporal sequence with:

- a first step F_1 (Figures 1 and 2) of dipping of a plurality of metal bars B_0 of any class and diameter for use in the building sector present on the market (Figure 4) in a first tank V_1 containing a bituminous solution S_b, also referred to as cold solution S_b, the latter being kept at a temperature T_1 of between 6°C and 10°C, for a time interval Δt_1 of between one and two minutes in order to obtain bars impregnated with bitumen B_1 (Figure 5);
- an intermediate step F_2 of drying of the impregnated bars B_1 in air;
- a second step F_3 (Figures 1 and 3) of dipping of said impregnated bars B_1 (Figure 5) in a second tank V_2 containing a bituminous emulsion E_b, also referred to as hot emulsion E_b, the latter being kept in a thermal range ΔT_2 around 400°C, for a time interval Δt_2 of between one and two minutes in order to obtain bars impregnated and treated with the bituminous emulsion B_2 (Figure 6) ; and
- a final step F_4 of drying of said bars B_2 impregnated and treated with the bituminous emulsion (Figure 6) by leaving them to cool at ambient temperature T_A for a time interval Δt_3, variable as a function of the external temperature, from approximately ten minutes in winter to approximately twenty minutes in summer in order to obtain metal bars B (Figure 7) unattackable by corrosion and hence durable over time.

[0036] The metal bars B are preferably obtained using metal bars B_0 of any class and diameter for use in the building sector present on the market of the type made of low-alloy steel in so far as the steel bars used for providing a reinforcement are normally made of carbon steel and usually have a circular cross section (whence the common name of "rod"). Said commercially available bars B_0 are provided with an outer surface characterized by particular ribbings referred to as "knurlings", which have the function of improving adherence of the concrete of the concrete structure to the bars themselves. The bars thus obtained are referred to as "improved adherence" or "ribbed" bars and are commonly known by the name of "knurled rods".

[0037] Up to some decades ago, the standards envisaged also the use of smooth bars, and slipping inside the concrete was prevented with the formation at the ends of the bars themselves of hook-like bends that constituted internal anchorages proper.

[0038] The present invention can be applied in the building sector preferably in the field of reinforcements typical of structural elements, such as beams and columns, which are characterized by two series of reinforcement bars:

- longitudinal bars, arranged parallel to the axis of the element, both in the area subject to tensile stress and in the area subject to compressive stress with the main task of co-operating with the concrete in absorbing bending stresses or compressive-bending stresses (in the area subject to tensile stress, in view of the poor resistance to tensile stress of concrete, the bars B have the task of absorbing integrally the tensile stress, whilst the bars B subjected to compression have the main task of bestowing greater ductility on the structure, as likewise, in the case of beams, the bars B, in the area subject to compressive stress, are also used as bracket-support bars); and
- transverse bars (referred to as "brackets"), of smaller diameter than the longitudinal bars, arranged transversely with respect to the axis of the structure and having a triple function; namely, they enable maintenance in position of the longitudinal bars before and during pouring of the concrete, they take on the shear stresses to which the element is subjected, and they reduce the length of free deflection of the longitudinal bars B subjected to compression, preventing their buckling.

[0039] The choice of bars B_0 constituted by common low-alloy steels is justified in that they have a minimal cost on the building-sector market (belonging to this group are ordinary steels and prestressing steels), but the process P according to the present invention is applicable also on reinforcements with low sensitivity to corrosion, such as galvanized steels and stainless steels.

[0040] As regards stainless-steel reinforcements, it is pointed out that their high cost had so far recommended and limited their use only for building of structures in highly aggressive environmental conditions, above all linked to the presence of seawater or thawing salts, or else in cases where, owing to the importance of the structure, a very long service life is required (for example, longer than 100 years). But with the application of the present process it is possible to obtain an incomparable duration of the cementitious product also with low-alloy steel bars B_0.

[0041] Low-alloy steel B_0 for reinforced concrete is produced inplants also in the form of bars or rolls, meshes or lattices, for direct use on the building site or as basic elements for subsequent transformations. Consequently, the process P referred to in the present invention can be applied also to said commercial products present on the market in order to bestow thereon an excellent corrosion resistance.

[0042] The anti-oxidizing protective means of a bituminous type S_b-E_b, are obtained starting from bituminous substances, namely, mixtures of hydrocarbons of natural origin or of ones obtained by distillation in the processing of crude oil, or mixtures of both types of hydrocarbons.

[0043] It is recalled, merely by way of descriptive example, that bitumens can be of a natural or distilled type.

[0044] Natural bitumens, found in oil fields in dark-to-black masses, usually impregnate porous rocks and derive from a natural distillation at low temperature occurring in the course of millennia in crude oils surfacing and coming into contact with atmospheric oxygen. In fact, the first materials used by men for impermeabilization were precisely poured asphalts, constituted by a mixture of aggregates and bitumens. These mixtures also exist in the natural state in Abruzzo and Sicily (Ragusa) and, subjected to compression with purposely provided technological means, were reduced into "cakes", referred to as "asphalt cakes", which today are no longer used.

[0045] Distilled bitumens derive from artificial distillation, at high temperature and in a few hours, of crude oil. Distilled bitumens are today used in all works of impermeabilization for laying road surfaces, etc.

[0046] Said bitumens, in production plants, are poured into tankers at a temperature of approximately 100°C, transported toconcrete-mixingplants, and poured into large tanks, where they remain at the same temperature, ready for use. For road works, said bitumens are prepared with aggregate to form the bituminous conglomerates, whereas for works of impermeabilization, the bitumens are poured into purposely provided drums and cooled. Subsequently, the drums are transported to the places of use, where they are heated to a temperature of approximately 300°C and then spread on terraces, bridges under construction, etc., to form bituminous coatings. Today, however, traditional bituminous coatings have been replaced by prefabricated ones, the membranes, which are more convenient to transport and install and have found widespread use.

[0047] The classification of bitumens takes into account the physico-chemical characteristics (softening temperature, penetration, viscosity, ductility, flammability, solubility in various solvents, etc.).

[0048] Natural bitumen is frequently mixed with artificial bitumen remaining from the distillation of crude oils with pitch or tar; hence, it is no longer possible to make a clear distinction between these various classes of compounds.

[0049] The distinction of the various natural bitumens is made according to their provenance, but also according to the distinction of use. The characteristics of natural bitumens are: solid or semi-solid consistency; hardness; colour; and variable volatility. Natural bitumens burn with a sooty flame, soften with heat, acquiring binding properties, are impermeable to water, insulating, and resistant to atmospheric agents, and have a good degree of consistency.

[0050] Given the above characteristics of natural and artificial bitumens, the industrial production process P referred to in the present document has been devised, applying the idea of protecting commercially available steel bars B_0 with anti-oxidizing protective means of a bituminous type S_b-E_b, which can be applied by dipping the steel bars themselves in bituminous solutions and emulsions.

[0051] It is here pointed out that:

- by "solution" is meant dissolving of a substance, whether solid or liquid, in another liquid, where the substance in excess is referred to as "solvent" and the substance in defect is referred to as "solute"; whereas
- by "emulsion" is meant a suspension in the form of small drops (in discontinuous phase) of one liquid in another liquid (in continuous phase) not mixable with the first (for example, the emulsion of oil in water). The stability of an emulsion depends upon numerous factors, such as: size of the particles, difference of density of the two phases (discontinuous phase and continuous phase), temperature conditions, agitation during conservation, mode of preparation, etc., but above all upon the nature and amount of the stabilizing or emulsifying agent.

[0052] In the light of the foregoing, it has been found that bitumen can be prepared in different ways, according to the startingpoint (temperature range) of its degree of softening. The first type is obtained at 30°C/50°C, the second at 50°C/70°C, and the third at 70°C/100°C. The second type with softening between 50°C and 70°C, precisely on account of its degree of softening, is better suited to obtaining a greater fluidity as compared to the other two types and, consequently, in this temperature range, the so-called oxidized or blown bitumen is obtained.

[0053] Oxidized bitumen is a product obtained by causing oxygen or air to act in hot conditions, to produce an increase in the index of penetration in so far as a more plastic mass is obtained. Oxidation acts from the chemical standpoint by dehydrogenating the product and giving rise to compounds of higher molecular weight. Said oxidized bitumen is compressed and reduced to form cakes referred to as "oxidized-bitumen cakes" in order to obtain oxidizedbitumen ready for being softened to obtain the hot bituminous emulsion E_b.

[0054] The industrial process P for producing the metal bars B referred to in the present invention, as has already been said, preferably employs low-alloy steel bars B_0 currently used in buildings made of reinforced concrete and ready for use in cementitious conglomerate in the natural state (see Figure 4) and a pair of tanks V_1-V_2, the first one V_1 being used as impregnation tank and the second one V_2 as emulsion tank.

[0055] To enable a greater adherence of the emulsion, the steel bars (or rods) B_0 ready for use are dipped mechanically in a metal tank of dimensions suitable for the processing environment and with the required amount, containing an appropriate solution, referred to as "cold bituminous solution" S_b, which, according to the present invention, has a base of oxidized bitumens and fast-drying technical solvents of a known type, also referred to as bituminous impregnating solution S_b.

[0056] The temperature T_1 of this bituminous solution S_b is preferably between 6°C and 10°C, and the time interval Δt_1 is between one and two minutes.

[0057] During a period of suspension of work or during holidays, it is necessary to take the precaution of covering the impregnation tank V_1 with a thin metal plate to prevent evaporation of the bituminous solution S_b.

[0058] The steel bars B_0, which are at ambient temperature, for the bituminous impregnation step F_1 are dipped in the tank V_1 (step F_1), which is preferably constituted by a metal tank having dimensions of approximately 20 metres in length and 10 metres in width and contains the cold bituminous solution S_b.

[0059] The steel bars B_0 are then dipped in the cold bituminous solution S_b, remaining therein for some minutes, preferably for one or at the most two minutes.

[0060] After said dipping, they are removed from the bath and left in the air to dry for the time necessary (step F_2).

[0061] Once dried, the steel bars impregnated with the cold bituminous solution B_1 are dipped in the emulsion tank V_2 (step F_3), which is also preferably constituted by a metal tank having the dimensions of approximately 20 metres in length and 10 metres in width and contains the hot bituminous emulsion E_b, where the bars will remain for approximately another two minutes.

[0062] The second metal tank V_2 contains the hot bituminous emulsion at a controlled temperature T_2 of between 350°C and 450°C, preferably approximately 400°C, where the bars B_1, as has been said, remain for a time interval Δt_2 of between approximately one and two minutes.

[0063] The bituminous emulsion E_b at said temperature is very fluid and acquires the function of binder.

[0064] The bars, thus impregnated and treated with the bituminous emulsion B_2, are lifted out and left hanging the time necessary for drying (step F_4), leaving them to cool at ambient temperature T_A for a time interval Δt_3 that varies as a function of the external temperature from approximately ten minutes in winter to approximately twenty minutes in summer in order to obtain metal bars B that are unattackable by corrosion and hence durable over time.

[0065] The steel bars B, thus impregnated, treated with the bituminous emulsion and dried, are ready for being loaded onto lorries for their subsequent transport to the building sites. For a correct loading and transport of the bars B, it is envisaged to separate them with a sheet of polyethylene to prevent any rise in temperature from possibly heating the layer of bituminous emulsion and to prevent the bars themselves from "sticking", i.e., adhering to one another.

[0066] Likewise provided is at least one pair of means for lifting, dipping, and translation M_S of the bars B_0-B_1-B_2-B, as emerges from Figure 1, provided with mechanisms designed to:

- dip the steel bars B_0 in the tank V_1 to impregnate them with the cold bituminous solution S_b (step F_1);
- lift the impregnated bars B_1 out of the tank V_1, leaving them to dry in air (step F_2) and then translate them into the tank V_2 for subsequent dipping in the hot bituminous emulsion E_b (step F_3);
- lift the bars impregnated and treated with the bituminous emulsion B_2 out of the latter tank V_2, keeping them in air in order to dry (step F_4), thus obtaining the bars B referred to in the present invention, which can then be prepared for being loaded on lorries for transport to building sites or for warehousing.

[0067] The bars B obtained with this process present the advantage that they can also subsequently be curved and bent, according to the need, in so far as the hot bituminous emulsion at a temperature of approximately 400°C coats the steel bar with a given thickness, perfectly compatible for said operations and for being used with the cementitious conglomerate for building reinforced-concrete structures.

[0068] In the case where it is desired to obtain a greater thickness of the bituminous emulsion, it is necessary to reduce the temperature range ΔT_2 of the hot emulsion from values of around 400°C to values of around 300°C or, alternatively, dip the steel bars B_2 for a second time in the same tank of bituminous emulsion V_2 in order to obtain a second layer of bituminous emulsion, which, beingdeposited over the first, bestows said greater thickness.

[0069] Not recommended, instead, are further baths in the emulsion tank in so far as this could jeopardize the necessary cohesion between the cementitious conglomerate and the bars B, necessary for obtaining an optimal resistance of the reinforced-concrete structure that is to be obtained.

[0070] It is envisaged that, with the solution devised, the steel bars are practically invulnerable over time in so far as, whereas the cementitious conglomerate with the passage of centuries will tend in any case to crumble and in part to pulverize, the steel bars, impregnated first with the cold bituminous solution and then with the hot bituminous emulsion, will remain intact.

[0071] Consequently, the basic advantage of the present invention is to have devised an industrial production process that renders the steel bars (or in general the metal bars) unalterable over time, enabling a marked binding power and adherence to be obtained between the bars and the cementitious conglomerate in reinforced-concrete structures, high resistance to atmospheric agents, and unlimited durability over time.

[0072] Another advantage, no less important than the previous one, is represented by the fact that the steel bars thus treated preserve in any case the properties of resistance (tensile strength, compressive strength, etc.) to the same degree as non-treated ones, thus preventing the need to demolish buildings, hotels, and skyscrapers on account of the advanced state of corrosion of the iron constituting the elements made of steel, since the steel bars thus treated will resist much longer than known ones, being even indestructible over time.

[0073] As emerges from the foregoing description and from the attached figures, the further advantages of the bars referred to in the present invention derive precisely also from the simplicity of industrial production on account of the constructional characteristics proper to the bars (as also to all the other steel elements constituting current reinforcements for building purposes, which could likewise undergo the same process of impregnation with the bituminous solution and emulsion), which thus leads to the further advantage of minimizing the production costs and hence the costs of installation and regulation (bending and cutting of the bars) on the building site.

[0074] It should be noted that the present invention can be applied to steel bars for building purposes both in steelworks, when they are produced, andindepots (warehouses, yards, etc.).

[0075] In the case of steelworks, the bars leaving the furnace will have to be preliminarily cooled to ambient temperature before being dipped in the cold bituminous solution S_b, whereas in the case where the bars are stored in depots, before dipping them in the cold bituminous solution S_b, it will be necessary to subject them to a preliminary treatment to eliminate the rust that usually forms on their outer surface. For example, pickling could be carried out or some other known treatment to eliminate rust or other substances (grease, oil, etc.) that could hinder proper adhesion of the protective layer that impregnates the bars.

[0076] The invention has, moreover, the undoubted advantage of enabling an optimization of the operation of protection of the bars against corrosion, likewise enabling total on-line automation of the production of the rods themselves or of other commercial products present on the market, also in the form of bars or rolls, meshes or lattices, for their direct use on building sites or as basic elements for subsequent transformations; for this reason the process according to the present invention can be applied also to said commercial products.

[0077] It is also evident that numerous modifications, adaptations, integrations, variations, and replacement of elements with other functionally equivalent ones may be made to the embodiment described herein purely by way of illustrative and non-limiting example, without thereby departing from the sphere of protection defined by the ensuing claims.

LEGEND

[0078]

(B_0) metal bars for use in the building sector present on the market
(B_1) bars impregnated with bituminous solution
(B_2) bars treated with bituminous emulsion
(B) metal bars referred to in the present invention
(P) industrial production process
(S_b, E_b) anti-oxidizing protective means of a bituminous type
(S_b) bituminous solution or cold solution
(E_b) bituminous emulsion or hot emulsion
(F_1) impregnation step
(F_2) step of treatment with emulsion
(F_3) drying step
(V_1) impregnation tank
(V_2) emulsion tank
(T_1) thermal range of impregnation
(Δt_1) impregnation time
(T_2) thermal range of emulsion
(Δt_2) emulsion-treatment time
(T_A) ambient temperature
(Δt_3) drying time
(M_S) means for lifting, dipping, and translation of the bars (T) articulated lorries for transporting the bars

Claims

1. A metal bar (B) of any class and diameter for use in the building sector for steel structural work or for reinforcements, obtained via a treatment process (P) that envisages application thereon of anti-oxidizing protective means of a bituminous type (S_b, E_b), compatible in an optimal way also with any type of concrete, for building structures with and without reinforced concrete, unattackable by corrosion and hence durable over time, **characterized in that** it is obtained via a treatment (P) that envisages impregnation of the bar itself with an oxidized bitumen-based bituminous solution (S_b) and a bituminous emulsion (E_b) obtained via:

- a first dipping (F_1) of one or more metal bars at ambient temperature (B_0) in a first tank (V_1), containing an oxidized bitumen-based bituminous solution (S_b) and fast-drying technical solvents, referred to also as "cold solution (S_b)", the latter being kept at a temperature (T_1) of between 6°C and 10°C, for a time interval (Δt_1) of between one and two minutes, in order to obtain bars impregnated with bitumen (B_1);
- a first drying (F_2) of the impregnated bars (B_1) in air;
- a second dipping (F_3) of said impregnated bars (B_1) in a second tank (V_2) containing a bitumi-

nous emulsion (E_b), also referred to as "hot emulsion (E_b)", the latter being kept at a temperature (T_2) of between 350°C and 450°C, preferably approximately 400°C, for a time interval (Δt_2) of between one and two minutes, in order to obtain bars impregnated and treated with the bituminous emulsion (B_2); and

- a final step (F_4) for drying said bars impregnated and treated with the bituminous emulsion (B_2), leaving them to cool at ambient temperature (T_A) for a time interval (Δt_3), variable as a function of the ambient temperature (T_A), from approximately ten minutes in winter to approximately twenty minutes in summer in order to obtain metal bars (B) unattackable by corrosion and hence durable over time.

2. A process for the treatment of metal bars (B) of any class and diameter for use in the building sector, for steel structural work or for reinforcements, **characterized in that** it envisages impregnation of said bars with an oxidized bitumen-based bituminous solution (S_b) and a bituminous emulsion (E_b) obtained via:

- a first dipping (F_1) of one or more metal bars at ambient temperature (B_0) in a first tank (V_1), containing an oxidized bitumen-based bituminous solution (S_b) and fast-drying technical solvents, also referred to as "cold solution (S_b)", the latter being kept at a temperature (T_1) of between 6°C and 10°C, for a time interval (Δt_1) of between one and two minutes in order to obtain bars impregnated with bitumen (B_1);
- a first drying (F_2) of the impregnated bars (B_1) in air;
- a second dipping (F_3) of said impregnated bars (B_1) in a second tank (V_2) containing a bituminous emulsion (E_b), also referred to as "hot emulsion (E_b)", the latter being kept at a temperature (T_2) of between 350°C and 450°C, preferably approximately 400°C, for a time interval (Δt_2) of between one and two minutes, in order to obtain bars impregnated and treated with the bituminous emulsion (B_2); and
- a final step (F_4) for drying said bars impregnated and treated with the bituminous emulsion (B_2), leaving them to cool at ambient temperature (T_A) for a time interval (Δt_3), variable as a function of the ambient temperature (T_A), from approximately ten minutes in winter to approximately twenty minutes in summer, in order to obtain metal bars (B) unattackable by corrosion and hence durable over time.

3. The metal bar (B) according to Claim 1, **characterized in that** said cold bituminous solution (S_b) is constituted by natural and artificial bitumens that can currently be found on the market.

4. The metal bar (B) according to Claim 1, **characterized in that** said hot bituminous emulsion (E_b) is constituted by natural and artificial bitumens that can currently be found on the market.

5. The metal bar (B) according to Claim 1, **characterized in that** said cold bituminous solution (S_b) and said hot bituminous emulsion (E_b) can be substituted over time with solutions and emulsions constituted by other substances available in nature, but equivalent, such as anti-oxidizing protective means, designed to protect the bars themselves or other metal structural elements from corrosion.

6. The metal bar (B) according to Claim 1, **characterized in that** it is obtained preferably using metal bars of the type made of low-alloy steel (B_0) of any class and diameter for use in the building sector present on the market.

7. The process (P) according to Claim 2, **characterized in that** it envisages the use of means for lifting, dipping, and translation of the bars (M_S), designed to render the production process (P) itself completely automatic.

8. The process (P) according to Claim 2, **characterized in that** is industrially automatable and applicable not only to said commercially available low-alloy bars (B_0), but also to other types of metal structural elements present on the market different from bars, such as for example rolls, meshes and lattices.

Patentansprüche

1. Metallstab (B) von beliebiger Klasse und Durchmesser zur Verwendung im Bausektor für Stahlfachwerk oder für Armierungen, der erhalten wird durch ein Behandlungsverfahren (P), bei dem die Anwendung eines Oxidationsschutzmittels bituminöser Art (S_b, E_b) beabsichtigt ist, der auch mit jeder Betonsorte in optimaler Weise für Bauwerke mit und ohne Stahlbeton kombinierbar, nicht durch Korrosion angreifbar und damit dauerfest ist, **dadurch gekennzeichnet, dass** er über eine Behandlung (P) erhalten wird, bei der eine Tränkung des Stabes selbst mit einer Bitumenlösung (S_b) auf Basis oxidierten Bitumens und einer Bitumenemulsion (E_b) beabsichtigt ist und die erreicht wird durch:

- erstes Eintauchen (F_1) eines oder mehrerer Metallstäbe (B_0) bei Umgebungstemperatur in einen ersten Behälter (V_1), der eine Bitumenlösung (S_b) auf Basis oxidierten Bitumens und schnell trocknende technische Lösungsmittel enthält, auch als "Kaltlösung (S_b)" bezeichnet, wobei letztere für einen Zeitraum (Δt_1) von zwischen einer und zwei Minuten auf einer Temperatur (T_1) von zwischen 6°C und 10°C gehalten wird, um mit Bitumen getränkte Stäbe (B_1) zu bekommen;

- erstes Trocknen (F_2) der getränkten Stäbe (B_1) in Luft;
- zweites Eintauchen (F_3) der getränkten Stäbe (B_1) in einen zweiten Behälter (V_2), der eine auch als "Heißemulsion (E_b)" bezeichnete Bitumenemulsion (E_b) enthält, wobei letztere für einen Zeitraum (Δt_2) von zwischen einer und zwei Minuten auf einer Temperatur (T_2) von zwischen 350°C und 450°C, vorzugsweise etwa 400°C, gehalten wird, um mit der Bitumenemulsion getränkte und behandelte Stäbe (B_2) zu bekommen; und
- einen letzten Schritt (F_4) zum Trocknen der mit der Bitumenemulsion getränkten und behandelten Stäbe (B_2), indem sie zum Abkühlen bei einer Umgebungstemperatur (T_A) einen als Funktion der Umgebungstemperatur (T_A) veränderlichen Zeitraum (Δt_3) lang von etwa zehn Minuten im Winter bis etwa zwanzig Minuten im Sommer liegen gelassen werden, um Metallstäbe (B) zu erhalten, die durch Korrosion nicht angreifbar und damit dauerfest sind.

2. Verfahren zur Behandlung von Metallstäben (B) von beliebiger Klasse und Durchmesser zur Verwendung im Bausektor, für Stahlfachwerk oder Armierungen, **dadurch gekennzeichnet, dass** eine Tränkung der Stäbe mit einer Bitumenlösung (S_b) auf Basis oxidierten Bitumens und einer Bitumenemulsion (E_b) beabsichtigt ist, die erreicht wird durch:

- erstes Eintauchen (F_1) eines oder mehrerer Metallstäbe bei Umgebungstemperatur (B_0) in einen ersten Behälter (V_1), der eine Bitumenlösung (S_b) auf Basis oxidierten Bitumens und schnell trocknende technische Lösungsmittel enthält, auch als "Kaltlösung (S_b)" bezeichnet, wobei letztere für einen Zeitraum (Δt_1) von zwischen einer und zwei Minuten auf einer Temperatur (T_1) von zwischen 6°C und 10°C gehalten wird, um mit Bitumen getränkte Stäbe (B_1) zu bekommen;
- erstes Trocknen (F_2) der getränkten Stäbe (B_1) in Luft;
- zweites Eintauchen (F_3) der getränkten Stäbe (B_1) in einen zweiten Behälter (V_2), der eine auch als "Heißemulsion (E_b)" bezeichnete Bitumenemulsion (E_b) enthält, wobei letztere für einen Zeitraum (Δt_2) von zwischen einer und zwei Minuten auf einer Temperatur (T_2) von zwischen 350°C und 450°C, vorzugsweise etwa 400°C, gehalten wird, um mit der Bitumenemulsion getränkte und behandelte Stäbe (B_2) zu bekommen; und
- einen letzten Schritt (F_4) zum Trocknen der mit der Bitumenemulsion getränkten und behandelten Stäbe (B_2), indem sie zum Abkühlen bei einer Umgebungstemperatur (T_A) einen als Funktion der Umgebungstemperatur (T_A) veränderlichen Zeitraum (Δt_3) lang von etwa zehn Minuten im Winter bis etwa zwanzig Minuten im Sommer liegen gelassen werden, um Metallstäbe (B) zu bekommen, die durch Korrosion nicht angreifbar und damit dauerfest sind.

3. Metallstab (B) nach Anspruch 1, **dadurch gekennzeichnet, dass** die kalte Bitumenlösung (S_b) durch Naturbitumen und künstliches Bitumen gebildet wird, die gegenwärtig auf dem Markt beschafft werden können.

4. Metallstab (B) nach Anspruch 1, **dadurch gekennzeichnet, dass** die heiße Bitumenemulsion (E_b) durch Naturbitumen und künstliches Bitumen gebildet wird, die gegenwärtig auf dem Markt beschafft werden können.

5. Metallstab (B) nach Anspruch 1, **dadurch gekennzeichnet, dass** die kalte Bitumenlösung (S_b) und die heiße Bitumenemulsion (E_b) im Lauf der Zeit durch Lösungen und Emulsionen ersetzt werden können, die durch andere in der Natur vorhandene aber äquivalente Substanzen gebildet werden können wie beispielsweise Oxidationsschutzmittel, die dazu bestimmt sind, die Stäbe selbst oder andere metallene Konstruktionselemente vor Korrosion zu schützen.

6. Metallstab (B) nach Anspruch 1, **dadurch gekennzeichnet, dass** er vorzugsweise durch Verwendung von auf dem Markt vorhandenen Metallstäben des aus niedriglegiertem Stahl (B_0) von beliebiger Klasse und Durchmesser hergestellten Typs zur Verwendung im Bausektor erhalten wird.

7. Verfahren (P) nach Anspruch 2, **dadurch gekennzeichnet, dass** die Nutzung von Mitteln zum Anheben, Eintauchen und zur Parallelverschiebung der Stäbe (M_5) beabsichtigt ist, die ausgelegt sind, um den Produktionsprozess (P) selbst vollautomatisch zu machen.

8. Verfahren (P) nach Anspruch 2, **dadurch gekennzeichnet, dass** es nicht nur auf die kommerziell erhältlichen, niedriglegierten Stäbe (B_0) sondern auch auf andere Arten von auf dem Markt vorhandenen metallenen Konstruktionselementen, anders als Stäbe, wie zum Beispiel Rollen, Gewebe und Gitterwerke industriell automatisierbar und anwendbar ist.

Revendications

1. Barre de métal (B) de n'importe quelle classe et diamètre pour l'utilisation dans le secteur du bâtiment pour des travaux de construction métallique ou pour des renforcements, obtenue via un procédé de traitement (P) qui prévoit l'application sur celle-ci de moyens de protection contre l'oxydation d'un type bitumineux (S_b, E_b), compatibles d'une manière optimale également avec n'importe quel type de béton, pour des structures de construction avec et sans béton armé, inattaquables par corrosion et par conséquent durables dans le temps, **caractérisée en ce qu'**elle est obtenue via un traitement (P) qui prévoit l'imprégnation de la barre elle-même avec une solution bitumineuse à base de bitume oxydé (S_b) et une émulsion bitumineuse (E_b) obtenue via :

   - un premier trempage (F_1) d'une ou plusieurs barres de métal à température ambiante (B_0) dans une première cuve (V_1), contenant une solution bitumeuse à base de bitume oxydé (S_b) et des solvants techniques à séchage rapide, indiquée également comme « solution froide (S_b) », cette dernière étant maintenue à une température (T_1) comprise entre 6°C et 10°C, pendant un intervalle de temps (Δt_1) compris entre une et deux minutes, de manière à obtenir des barres imprégnées avec du bitume (B_1) ;
   - un premier séchage (F_2) des barres imprégnées (B_1) dans l'air ;
   - un deuxième trempage (F_3) desdites barres imprégnées (B_1) dans une deuxième cuve (V_2), contenant une émulsion bitumeuse (E_b), indiquée également comme « émulsion chaude (E_b) », cette dernière étant maintenue à une température (T_2) comprise entre 350°C et 450°C, de préférence approximativement 400°C, pendant un intervalle de temps (Δt_2) compris entre une et deux minutes, de manière à obtenir des barres imprégnées et traitées avec l'émulsion bitumineuse (B_2) ; et
   - une étape finale (F_4) pour sécher lesdites barres imprégnées et traitées avec l'émulsion bitumineuse (B_2), en les laissant refroidir à température ambiante (T_A) pendant un intervalle de temps (Δt_3), variable en fonction de la température ambiante (T_A), d'approximativement dix minutes en hiver à approximativement vingt minutes en été de manière à obtenir des barres de métal (B) inattaquables par corrosion et par conséquent durables dans le temps.

2. Procédé pour le traitement de barres de métal (B) de n'importe quelle classe et diamètre pour l'utilisation dans le secteur du bâtiment pour des travaux de construction métallique ou pour des renforcements, **caractérisé en ce qu'**il prévoit l'imprégnation desdites barres avec une solution bitumeuse à base de bitume oxydé (S_b) et une émulsion bitumeuse (E_b) obtenues via :

   - un premier trempage (F_1) d'une ou plusieurs barres de métal à température ambiante (B_0) dans une première cuve (V_1), contenant une solution bitumeuse à base de bitume oxydé (S_b) et des solvants techniques à séchage rapide, indiquée également comme « solution froide (S_b) », cette dernière étant maintenue à une température (T_1) comprise entre 6°C et 10°C, pendant un intervalle de temps (Δt_1) compris entre une et deux minutes, de manière à obtenir des barres imprégnées avec du bitume (B_1) ;
   - un premier séchage (F_2) des barres imprégnées (B_1) dans l'air ;
   - un deuxième trempage (F_3) desdites barres imprégnées (B_1) dans une deuxième cuve (V_2), contenant une émulsion bitumeuse (E_b), indiquée également comme « émulsion chaude (E_b) », cette dernière étant maintenue à une température (T_2) comprise entre 350°C et 450°C, de préférence approximativement 400°C, pendant un intervalle de temps (Δt_2) compris entre une et deux minutes, de manière à obtenir des barres imprégnées et traitées avec l'émulsion bitumineuse (B_2) ; et
   - une étape finale (F_4) pour sécher lesdites barres imprégnées et traitées avec l'émulsion bitumineuse (B_2), en les laissant refroidir à température ambiante (T_A) pendant un intervalle de temps (Δt_3), variable en fonction de la température ambiante (T_A), d'approximativement dix minutes en hiver à approximativement vingt minutes en été de manière à obtenir des barres de métal (B) inattaquables par corrosion et par conséquent durables dans le temps.

3. Barre de métal (B) selon la revendication 1, **caractérisée en ce que** ladite solution bitumineuse froide (S_b) est constituée par des bitumes naturels et artificiels qui peuvent être trouvés actuellement sur le marché.

4. Barre de métal (B) selon la revendication 1, **caractérisée en ce que** ladite émulsion bitumineuse chaude (E_b) est constituée par des bitumes naturels et artificiels qui peuvent être trouvés actuellement sur le marché.

5. Barre de métal (B) selon la revendication 1, **caractérisée en ce que** ladite solution bitumineuse froide (S_b) et ladite émulsion bitumineuse chaude (E_b) peuvent être remplacées dans le temps par des solutions et émulsions constituées par d'autres substances disponibles dans la nature, mais équivalentes, telles que des moyens de protection contre l'oxyda-

tion, conçus pour protéger de la corrosion les barres elles-mêmes ou d'autres éléments de construction métalliques.

6. Barre de métal (B) selon la revendication 1, **caractérisée en ce qu'**elle est obtenue de préférence en utilisant des barres de métal du type réalisé en acier faiblement allié (B_0) de n'importe quelle classe et diamètre pour l'utilisation dans le secteur du bâtiment, présent sur le marché.

7. Procédé (P) selon la revendication 2, **caractérisé en ce qu'**il prévoit l'utilisation de moyens pour le levage, le trempage et la translation des barres (M_S), conçus pour rendre le processus de production (P) lui-même complètement automatique.

8. Procédé (P) selon la revendication 2, **caractérisé en ce qu'**il est automatisable industriellement et applicable non seulement auxdites barres faiblement alliées disponibles sur le marché (B_0), mais également à d'autres types d'éléments de construction métalliques présents sur le marché différents des barres, tels que par exemple des rouleaux, grillages et treillis.

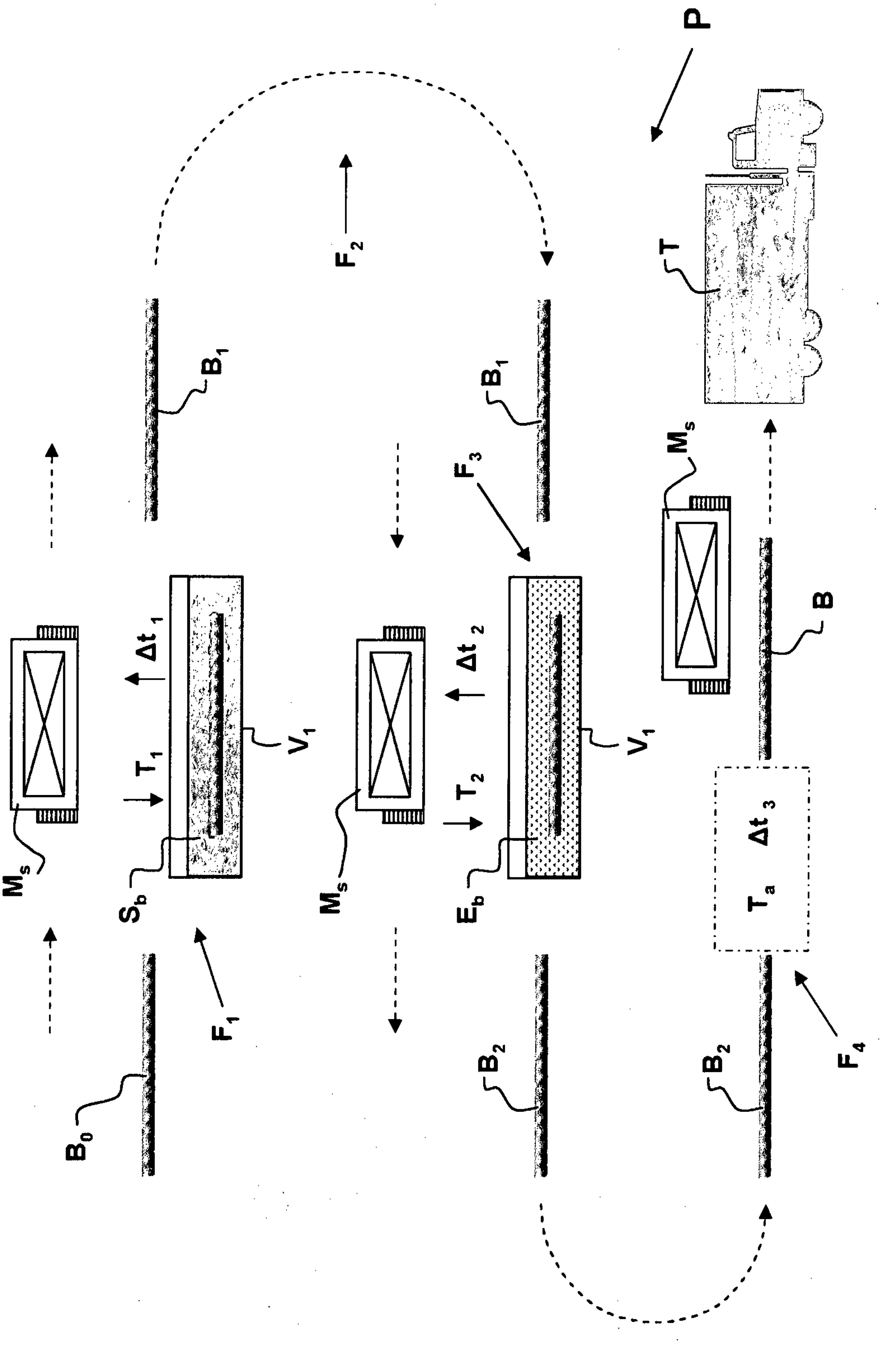
P
T
F_2
B_1
B_1
F_3
M_s
B
Δt_1
Δt_2
V_1
V_1
T_1
T_2
M_s
M_s
S_b
E_b
T_a
Δt_3
F_1
F_4
B_0
B_2
B_2

Fig.1

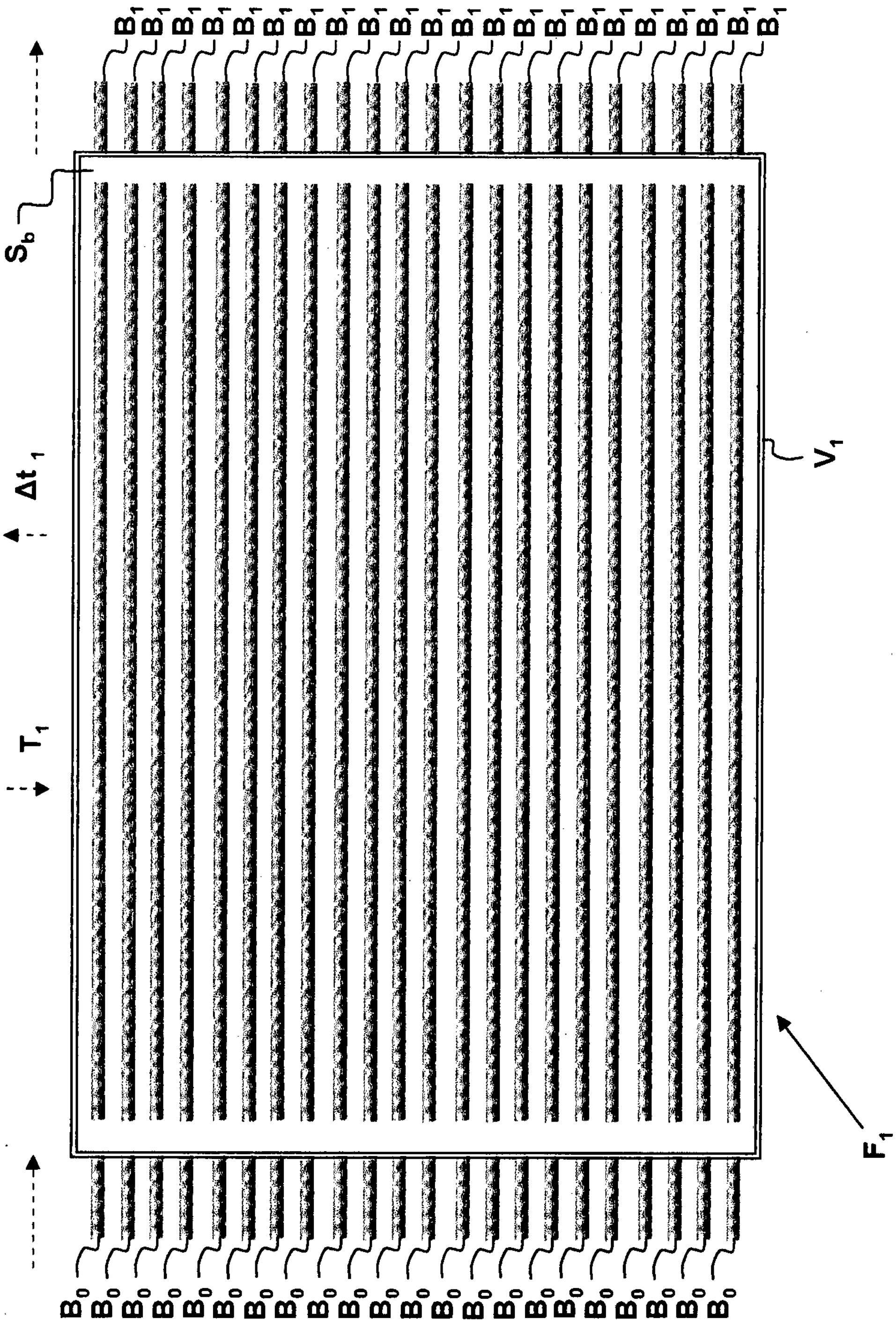

Fig.2

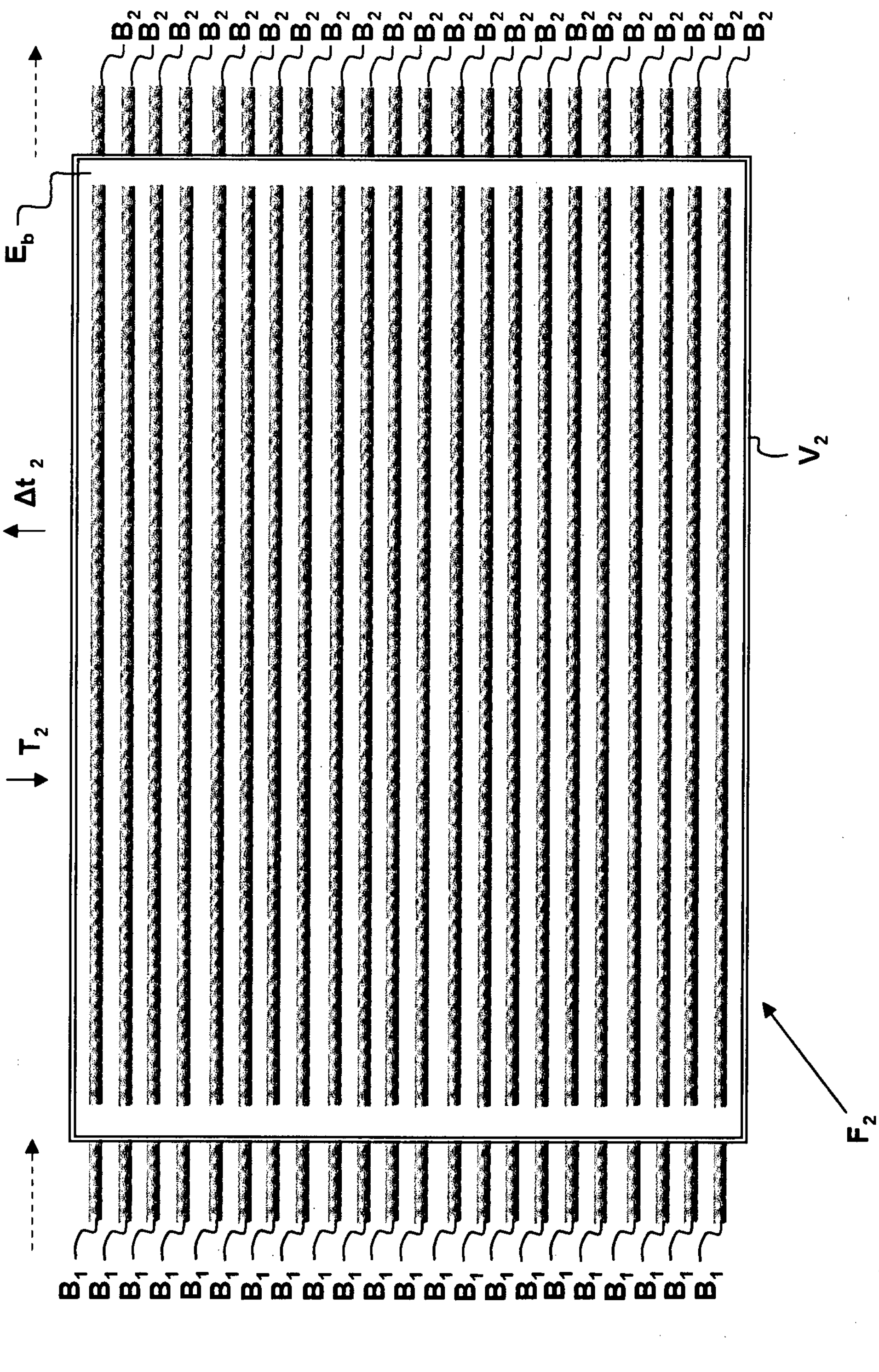

Fig.3

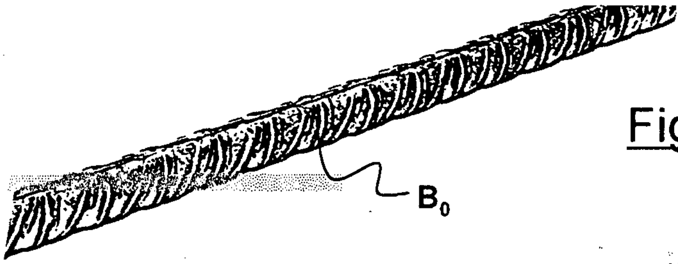

Fig.4

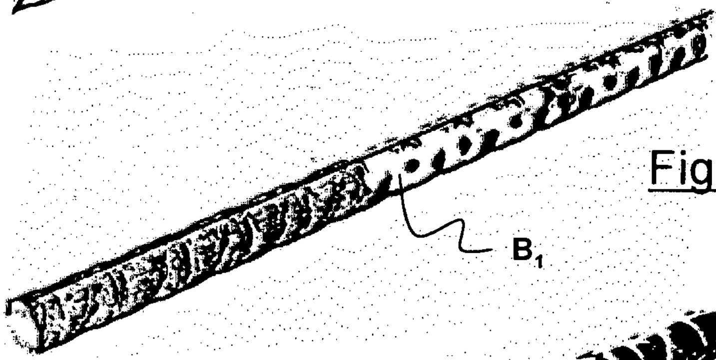

Fig.5

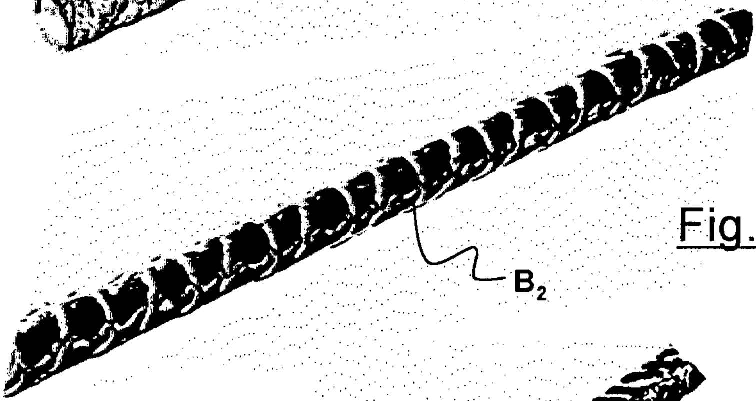

Fig.6

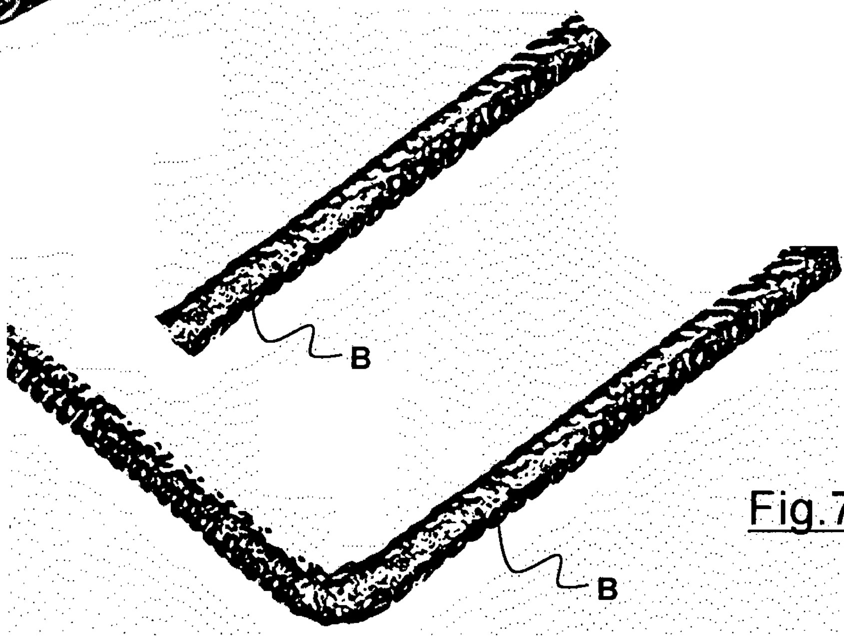

Fig.7

REFERENCES CITED IN THE DESCRIPTION

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