

# PATENT SPECIFICATION

DRAWINGS ATTACHED

904773

Date of Application and filing Complete Specification June 8, 1960.

No. 20211/60.

Application made in Germany (No. T16798) on June 10, 1959.

Complete Specification Published Aug. 29, 1962.



Index at acceptance:—Classes 20(4), G2, and 83(2), A137.

International Classification:—E04c. B23p.

## COMPLETE SPECIFICATION

### Improvements in or relating to Reinforcement Bars for Concrete

We, TOR-ISTEG STEEL CORPORATION S.A.H., a corporate body organised under the laws of the Grand Duchy of Luxemburg, of 19, Rue Aldringer, Luxemburg, 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:—

10 This invention relates to reinforcing bars for concrete, each bar having a core, at least one continuous longitudinal rib which is made to extend helically around the core by twisting, and oblique lugs, on the core periphery, which are separate from the longitudinal rib.

15 Reinforcing bars provided with transverse and oblique ribs which terminate in the flanks of longitudinal ribs and are inclined very considerably with respect to the bar axis, may give a very good bonding effect but also involve considerable disadvantages. Transverse ribs constitute a thickened portion extending around the core of the bar over short lengths. This provides local resistance to free deformation by torsion, and this results in stress peaks at the sloping surfaces where the flanks of the transverse ribs merge into the core surface. When the bars are subsequently bent, the notch effect of the transverse ribs results in further stress peaks at these regions, which are further considerably increased if the bending roller impinges against a transverse rib, which is practically unavoidable. The result is an increased tendency of such bars to brittle fractures, and defective reliability at the building site. Furthermore, the arrangement of oblique ribs which merge in the longitudinal ribs produces stress peaks at the places where the oblique ribs merge in the longitudinal ribs, since alteration of the angle at these places is prevented when the bar is twisted. Although oblique ribs reduce the danger of brittle fracture to some extent as

compared with transverse ribs, the reduction is not adequate.

It is known to prevent rotational movement in concrete of a reinforcing bar equipped with longitudinal, helical ribs, by means of axially parallel lugs on the surface of the core which are separate from the longitudinal ribs. The rollers employed for making these bars are provided with recesses for forming these lugs. These are cut into the rollers at an inclination to the bar axis which is equal to the angle between the helix line of the longitudinal ribs and the bar axis. When the bar is twisted, the lugs are twisted towards the bar axis and are situated approximately in the direction of the bar axis on the twisted bar. This arrangement does in fact improve the rotational slip characteristic of the reinforcing bar as compared with a bar having only helically extending longitudinal ribs. However, axially parallel lugs do not in every case completely prevent slipping. This is particularly true in the case of relatively thick bars.

The present invention is characterized in that the length of the peripheral component of the oblique lugs amounts to at least half of the core diameter, that the angular position of the said lugs deviates at least 5° from the parallel to the longitudinal rib and forms an angle  $\alpha$  of at least about 30° relatively to the bar axis in the twisted state, and that the flanks and end faces of the said lugs merge all around, after a steep descent, gently through rounded transitional portions into the core surface. In this way, the bonding effect of the bar in concrete is further improved since the lugs must additionally contribute to preventing displacement of the bar in the longitudinal direction. The dimensions of the oblique lugs and their inclination are such that the ability of the bar to bend is not reduced. The fatigue strength of such a reinforcing bar is also not detrimentally influenced. The danger of

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brittle fracture is reduced compared with known reinforcing bars having axially parallel lugs. The slip characteristic of the reinforcing bar of the present invention is increased in rigidity, i.e. less slip occurs for a given load, but is still low enough to give adequate warning of impending fracture by relatively considerable deformations prior to actual slip fracture.

In order to obtain a good bond between our bar and concrete, the oblique lugs should form as large an angle as possible relatively to the bar axis, but bearing in mind the danger of brittle fracture the inclination of the oblique lugs relatively to the bar axis must not, again, be too great. It has been found that an inclination of the oblique lugs of between  $30^\circ$  and  $50^\circ$  relatively to the bar axis in the twisted state is adequate for bonding and is not detrimental to pliability. There are also other desirable requirements for increasing bonding efficiency, namely that the oblique lugs should be as long as possible, should have as steep flanks as possible and should, as far as possible, be given a constant height over substantially their entire length, whilst in order to avoid stress peaks and to allow easy manufacture the oblique lugs should merge into the adjacent surfaces of the core through easy transitional portions or rounded-off surfaces along their entire periphery. It should also be ensured that the oblique lugs, as viewed in cross-section, have symmetrical flanks. Oblique lugs with angles of inclination up to  $50^\circ$  relatively to the bar axis can still be rolled-out symmetrically, and also do not prevent deformation when the bar is twisted. Although it is desirable to have as long oblique lugs as possible for improved bonding in concrete, the termination of the oblique lugs should not extend further than the beginning of the fillet of the longitudinal rib, which corresponds approximately to a distance of one-tenth of the core diameter. In reinforcing bars of different diameter and different degrees of twist, the length of the peripheral component of the oblique lugs can remain approximately the same independently of the inclination of the lugs relatively to the continuous longitudinal rib. The bonding effect and therefore the necessary number and inclination of oblique lugs depend on the quality of the steel, the quality of the concrete, and the core diameter. The higher the strength and therefore the permissible stressing of the steel, the better must the bonding action be, and the more numerous and/or the more inclined must the oblique lugs be. The bonding action must be better with a concrete of fairly low strength than for a concrete of fairly high strength. The bonding effect of a plain round bar depends on its diameter and is better in the case of thinner bars than in the case of relatively thick bars. The same also applies to reinforcing bars according to the invention. There-

fore, the number and/or inclination of the oblique lugs required for a specific minimum bonding effect must increase with bar diameter.

It has been found advantageous to fix the spacing of the oblique lugs by cutting lug-forming grooves in the rollers used in making the bars at a spacing of about 26 to 28 mm. which is the same for all core diameters for reinforcing bars. In this way, the relative density of the oblique lugs, i.e. the spacing of the lugs divided by the core diameter, is made to decrease with the core diameter, which meets the requirements of bonding in the sense that a better effect is anyway provided with increasing core diameter due to the greater peripheral surface area available. For example, the spacing, when measured along the length of the bars, and in the case of bars 20 mm. in thickness, amounts to about 1.4 times the core diameter, and is equal to the core diameter in the case of bars which are 26 mm. in thickness. Moreover, for example for bars of about 8 mm. in diameter the bonding effect of inclined lugs arranged at spacings amounting to four times the core diameter would be adequate. The inclination can be relatively slight, amounting to  $10^\circ$ . Bars which are 26 mm. in thickness, on the other hand, require oblique lugs inclined at about  $30$  to  $35^\circ$  at spacings equal to the core diameter. The spacing can be reduced to 0.5 times the bar diameter in the case of bars which are more than 26 mm. in thickness.

The height of the oblique lugs should amount to at least 0.05 of the core diameter (d). It is, however, preferred for the lugs to have a height of about 0.1 d, corresponding approximately to the height of the longitudinal rib. The height of the oblique lugs can also be made larger than the height of the continuous longitudinal rib. However, heights of more than 0.15 d do not afford any additional advantages. In order satisfactorily to fill the roller gap when rolling, i.e. in order to obtain oblique lugs whose contour corresponds to the negative contour cut in the rollers, certain measures are to be taken as regards the rolling process itself. The cross-section of the bar before the last pass, generally an oval cross-section, is to have a more compact form and the cross-sectional reduction in the last pass is to be rather greater than is conventional in the rolling of round bars. These measures are to be intensified with increasing height and slenderness of the oblique lugs. Too slight a cross-sectional reduction in the last pass has the result that the steel does not fully fill the form of the lugs during rolling, i.e. the lugs emerge with lower heights than were intended. Too pointed a shape in the oval has the result that only at the region of contact between the oval and the bottom of the roll groove are the lugs filled, in fact they are over-filled, as a result

of which part of the lugs are over-rolled and the remainder has an incomplete profile. Over-rolling gives rise, owing to notch effects, to brittle fractures during bending and is therefore to be avoided.

The oblique lugs preferably have a symmetrical form in longitudinal section and cross-section, merging into the core surface smoothly all round. If possible, the oblique lugs are to have steep flanks, the angle of which can be between  $40^\circ$  and  $80^\circ$ . The width of the oblique lugs at the base can amount to between 0.1 and 0.2 d. The fillets at the bottom of the flanks, as viewed in cross-section, are expediently given a radius of 0.02 to 0.03 d.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made to the accompanying diagrammatic drawings, in which:—

Figure 1 is an outside view of part of a reinforcing bar for concrete according to the invention,

Figure 2 is a section on the line II—II of Figure 1, and

Figure 3 illustrates a detail of Figure 2.

The reinforcing bar for concrete illustrated in the drawings comprises a core 1 and two continuous longitudinal ribs 2 and 3 which are made to extend helically around the core by twisting. Provided between these longitudinal ribs are oblique lugs 4.

The oblique lugs 4 do not terminate in the flanks of the longitudinal ribs 2 or 3, but advantageously end at a distance 5 from the longitudinal ribs, which distance can amount to about 0.1 d. Thus, with reinforcing bars having the usual core diameters of between 6 and 32 mm. this distance will amount to from about 0.6 to 3.2 mm.

The inclination  $\alpha$  of the oblique lugs 4 relatively to the longitudinal bar axis 6, designated by a chain-dotted line, is advantageously kept within the range of  $35^\circ$  to  $47^\circ$ . This ensures that the oblique position of the lugs is such that the length 10 of the peripheral component of the oblique lug 4 amounts to at least half of the core diameter. It is to be ensured that the deviation of the oblique lugs from the parallel to the longitudinal ribs amounts to at least  $5^\circ$ , in order to give an adequate guarantee against rotation in a concrete mass when the bar is subjected to stress. If the reinforcing bar is twisted by ten times d, i.e. one complete  $360^\circ$  twist in a bar length of 10 diameters, the inclination of the longitudinal rib 2 relatively to the longitudinal bar axis 6 will amount to an inclination  $\beta$  equal to about  $17^\circ$ . Thus, the oblique lugs 4 must be disposed at at least  $22^\circ$  in order to provide adequate security against turning movement. The angle  $\alpha$  will advantageously be chosen between  $30^\circ$  and  $35^\circ$ .

The spacing 7 of the oblique lugs from one another is, on an average, about the size of the diameter when measured along the length of the bar. In the case of relatively thin reinforcing bars the spacing apart can increase to four times d. With very thick reinforcing bars, the spacing apart of the oblique lugs can be reduced to about 0.5 d. It is also important that in the case of thin bars the oblique lugs should be so arranged that they overlap one another (Figure 1). This measure has the advantage that all the oblique lugs participate in the ability of the bar to withstand tensile stresses, i.e. no dead weight occurs such as is unavoidable with the conventional transverse and oblique ribs.

The flanks 8 of the oblique lugs 4 are to be made as steep as possible. The angle can be between about  $40^\circ$  and  $80^\circ$ . Even with steep flanks, a gentle transition should be provided to the peripheral surface of the core 1. The radius r of the rounded transition portion amounts expediently to between 0.02 and 0.03 d. The width b of the oblique lug 4 amounts to 0.1 to 0.2 d. The height h of the oblique lug 4 can be selected optionally from a range of 0.05 to 0.15 d. Advantageously, the height of the oblique lug corresponds to the height of the longitudinal ribs 2, 3, which can be about 0.1 d. The oblique lug 4 is to have a constant height over substantially its entire length. At the end, the oblique lug can terminate in a somewhat pointed tip. Alternatively, the oblique lug can also be provided with end faces which fall away in the same manner as the flanks 8.

#### WHAT WE CLAIM IS:—

1. A reinforcing bar for concrete, said bar having a core, at least one continuous longitudinal rib which is made to extend helically around the core by twisting the bar, and oblique lugs on the core periphery which are separate from the longitudinal rib, characterized in that the length of the peripheral component of the oblique lugs amounts to at least half of the core diameter, that the angular position of the said lugs deviates at least by  $5^\circ$  from the parallel to the longitudinal rib and forms an angle  $\alpha$  of at least about  $30^\circ$  relatively to the bar axis in the twisted state, and that the flanks and end faces of the said lugs merge all around, after a steep descent, gently through rounded translational portions into the core surface.

2. A reinforcing bar according to Claim 1, wherein the oblique lugs have an angle of inclination  $\alpha$  of at the most  $50^\circ$  relatively to the bar axis.

3. A reinforcing bar according to Claim 1 or 2, wherein the spacing of the oblique lugs from one another is approximately equal to the core diameter when measured along the length of the bar.

4. A reinforcing bar according to Claim 1 or 2, wherein, in reinforcing bars whose cores



*Transitional*



of which part of the lugs are over-rolled and the remainder has an incomplete profile. Over-rolling gives rise, owing to notch effects, to brittle fractures during bending and is therefore to be avoided.

The oblique lugs preferably have a symmetrical form in longitudinal section and cross-section, merging into the core surface smoothly all round. If possible, the oblique lugs are to have steep flanks, the angle of which can be between  $40^\circ$  and  $80^\circ$ . The width of the oblique lugs at the base can amount to between  $0.1$  and  $0.2$   $d$ . The fillets at the bottom of the flanks, as viewed in cross-section, are expediently given a radius of  $0.02$  to  $0.03$   $d$ .

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made to the accompanying diagrammatic drawings, in which:—

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The oblique lugs 4 do not terminate in the flanks of the longitudinal ribs 2 or 3, but advantageously end at a distance 5 from the longitudinal ribs, which distance can amount to about  $0.1$   $d$ . Thus, with reinforcing bars having the usual core diameters of between  $6$  and  $32$  mm, this distance will amount to from about  $0.6$  to  $3.2$  mm.

The inclination  $\alpha$  of the oblique lugs 4 relatively to the longitudinal bar axis 6, designated by a chain-dotted line, is advantageously kept within the range of  $35^\circ$  to  $47^\circ$ . This ensures that the oblique position of the lugs is such that the length 10 of the peripheral component of the oblique lug 4 amounts to at least half of the core diameter. It is to be ensured that the deviation of the oblique lugs from the parallel to the longitudinal ribs amounts to at least  $5^\circ$ , in order to give an adequate guarantee against rotation in a concrete mass when the bar is subjected to stress. If the reinforcing bar is twisted by ten times  $d$ , i.e. one complete  $360^\circ$  twist in a bar length of 10 diameters, the inclination of the longitudinal rib 2 relatively to the longitudinal bar axis 6 will amount to an inclination  $\beta$  equal to about  $17^\circ$ . Thus, the oblique lugs 4 must be disposed at at least  $22^\circ$  in order to provide adequate security against turning movement. The angle  $\alpha$  will advantageously be chosen between  $30^\circ$  and  $35^\circ$ .

The spacing 7 of the oblique lugs from one another is, on an average, about the size of the diameter when measured along the length of the bar. In the case of relatively thin reinforcing bars the spacing apart can increase to four times  $d$ . With very thick reinforcing bars, the spacing apart of the oblique lugs can be reduced to about  $0.5$   $d$ . It is also important that in the case of thin bars the oblique lugs should be so arranged that they overlap one another (Figure 1). This measure has the advantage that all the oblique lugs participate in the ability of the bar to withstand tensile stresses, i.e. no dead weight occurs such as is unavoidable with the conventional transverse and oblique ribs.

The flanks 8 of the oblique lugs 4 are to be made as steep as possible. The angle can be between about  $40^\circ$  and  $80^\circ$ . Even with steep flanks, a gentle transition should be provided to the peripheral surface of the core 1. The radius  $r$  of the rounded transition portion amounts expediently to between  $0.02$  and  $0.03$   $d$ . The width  $b$  of the oblique lug 4 amounts to  $0.1$  to  $0.2$   $d$ . The height  $h$  of the oblique lug 4 can be selected optionally from a range of  $0.05$  to  $0.15$   $d$ . Advantageously, the height of the oblique lug corresponds to the height of the longitudinal ribs 2, 3, which can be about  $0.1$   $d$ . The oblique lug 4 is to have a constant height over substantially its entire length. At the end, the oblique lug can terminate in a somewhat pointed tip. Alternatively, the oblique lug can also be provided with end faces which fall away in the same manner as the flanks 8.

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2. A reinforcing bar according to Claim 1, wherein the oblique lugs have an angle of inclination  $\alpha$  of at the most  $50^\circ$  relatively to the bar axis.

3. A reinforcing bar according to Claim 1 or 2, wherein the spacing of the oblique lugs from one another is approximately equal to the core diameter when measured along the length of the bar.

4. A reinforcing bar according to Claim 1 or 2, wherein, in reinforcing bars whose cores



*Transitional*

have a small diameter, e.g. 8 to 15 mm., the spacing apart of the oblique lugs amounts to three to four times said core diameter when measured along the length of the bar.

- 5 5. A reinforcing bar according to Claim 1 or 2, wherein, in the case of thick bars, e.g. having a core whose diameter exceeds 26 mm., the mutual spacing of the oblique lugs amounts to about half said core diameter when measured along the length of the bar.

10 6. A reinforcing bar according to Claim 1 or 2, wherein adjacent oblique lugs overlap one another.

- 15 7. A reinforcing bar according to Claim 1 or 2, wherein the oblique lugs are spaced apart lengthwise of the bar in the untwisted state by a distance of about 24 to 30 mm., preferably between 26 and 28 mm., independently of bar diameter.

- 20 8. A reinforcing bar according to any one of Claims 1 to 7, wherein the oblique lugs do not extend closer to the longitudinal rib than 0.1 of the core diameter.

9. A reinforcing bar according to any one of Claims 1 to 8, wherein the height of the oblique lugs amounts to at least 0.05, preferably 0.1, of the core diameter and remains approximately constant over substantially the entire length of the lugs.

10. A reinforcing bar according to any one of Claims 1 to 9, wherein the oblique lugs have a width at their crown of about 0.05 of the core diameter, wherein the rounded transitional portions at the base of the lugs are given a radius of 0.02 to 0.03 of the core diameter, and wherein the flanks of the lugs are inclined at an angle of between 40° to 80° relatively to the core surface.

11. A reinforcing bar for concrete, substantially as hereinbefore described with reference to the accompanying drawings.

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Leamington Spa: Printed for Her Majesty's Stationery Office by the Courier Press.—1962.  
Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.

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11 MAR 1965

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