US 20020189175A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2002/0189175 A1**

Lancelot, III et al. (43) **Pub. Date: Dec. 19, 2002**

(54) **END ANCHORS**

(76) Inventors: **Harry B. Lancelot III**, Centerville, OH (US); **Stephen B. Brown**, Merrimack, NH (US)

Correspondence Address:
Thomas W. Flynn,
2700 Carew Tower
441 Vine Street
Cincinnati, OH 45202 (US)

(21) Appl. No.: **09/881,956**

(22) Filed: **Jun. 15, 2001**

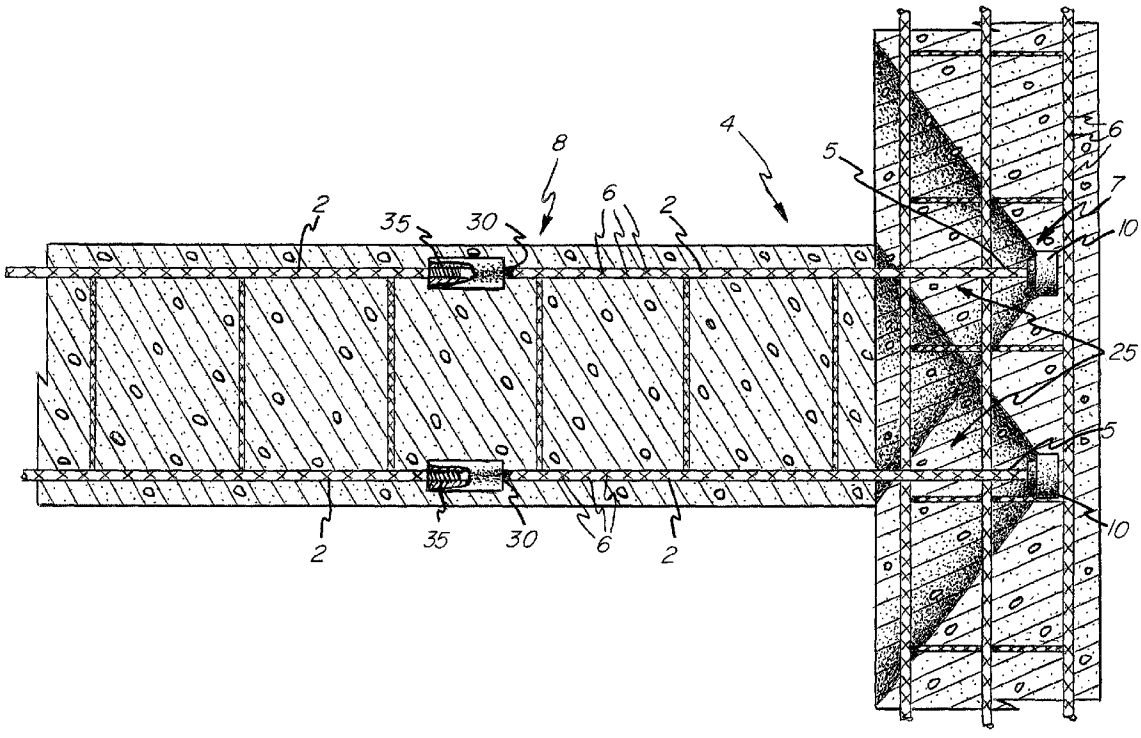
Publication Classification

(51) **Int. Cl.**[7] **E02D 5/74**; E04C 5/08; E02D 27/00; E02D 27/32; E04B 1/20; E04B 5/16

(52) **U.S. Cl.** **52/155**; 52/223.1; 52/223.14; 52/378; 52/698; 52/701; 52/295; 52/296; 52/319; 52/336; 52/340; 52/341

(57) **ABSTRACT**

An improved structural reinforcement bar for use in poured concrete construction has an anchorage plate fixed to a rebar body through friction welding. The friction welded rebar body and anchorage plate result in a structural reinforcement bar with improved axially oriented tensile load transfer capabilities having minimal space requirements.



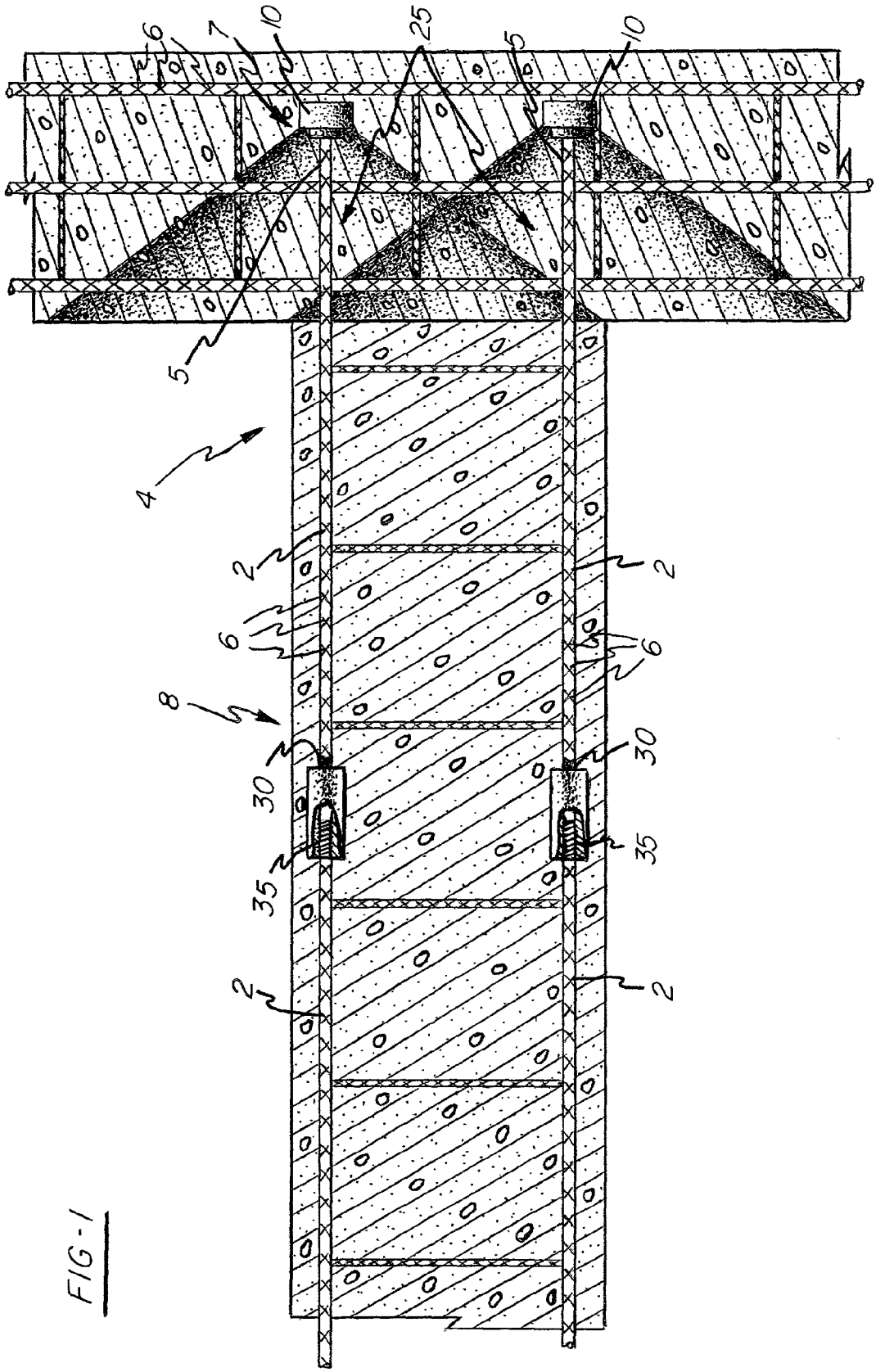


FIG-1

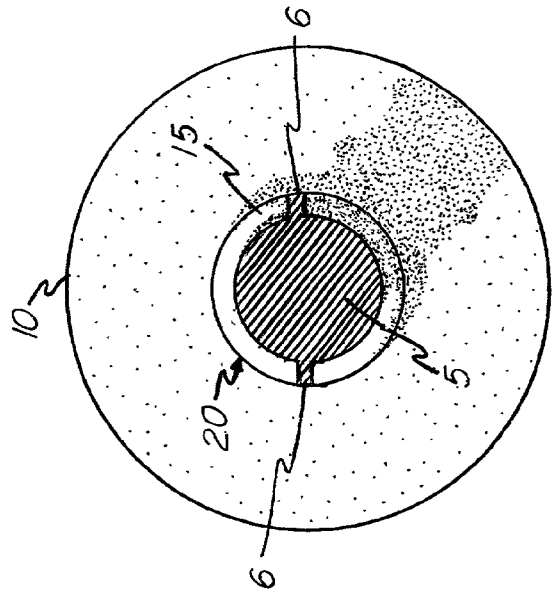


FIG - 3

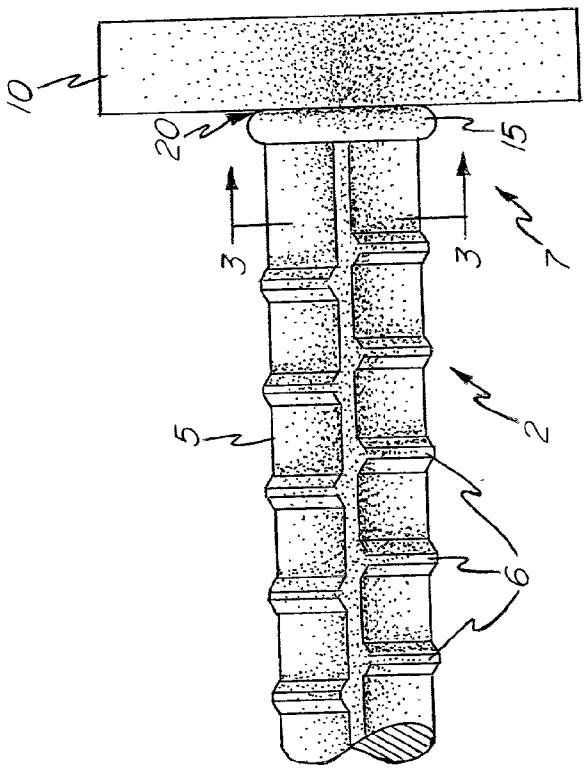


FIG - 2

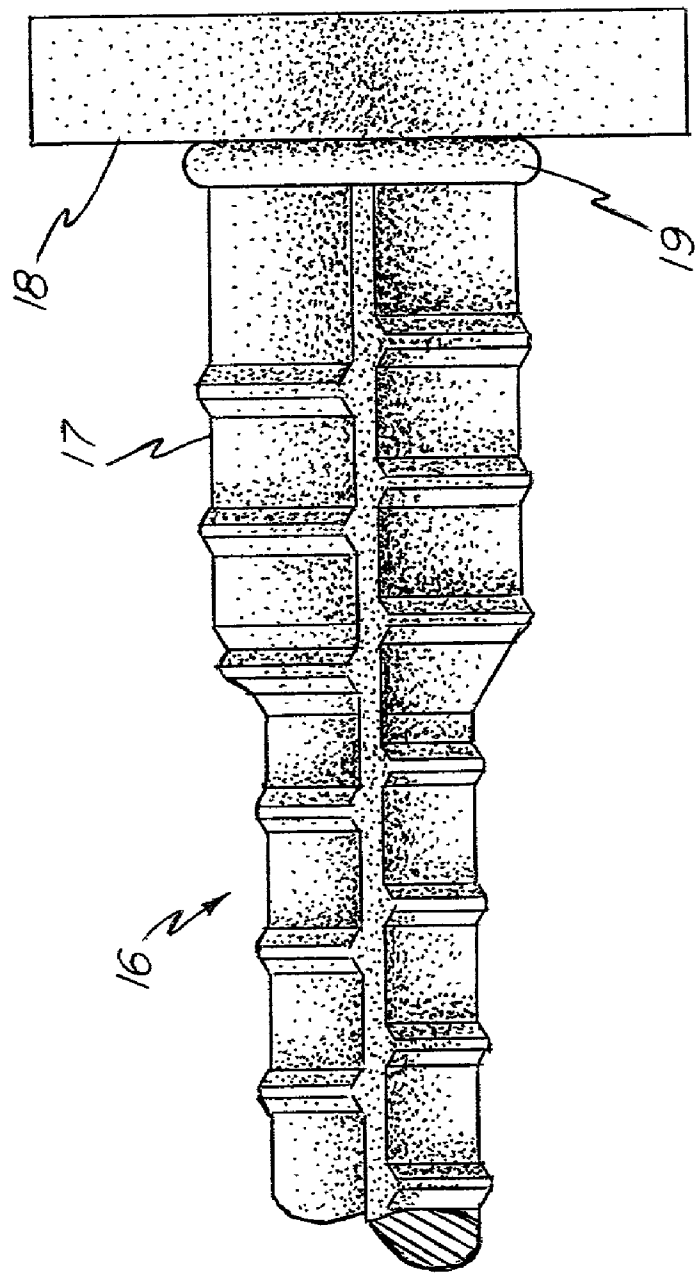


FIG - 4

FIG - 5

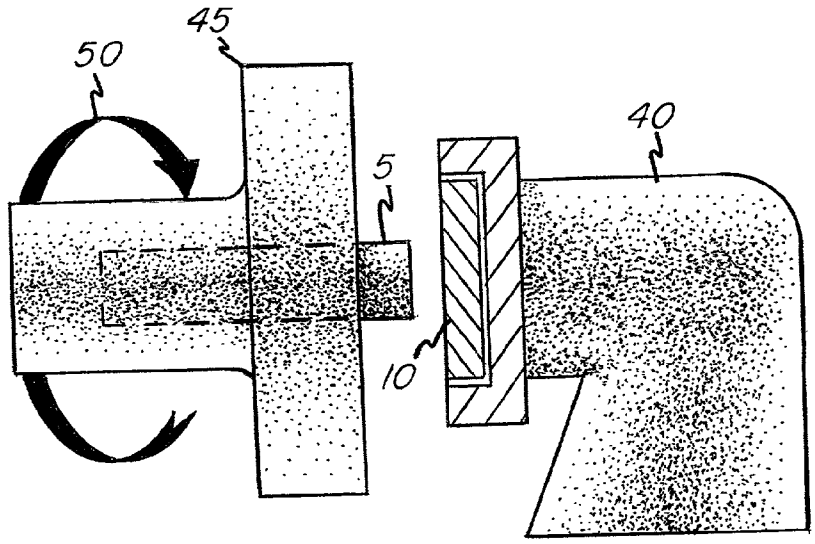


FIG - 6

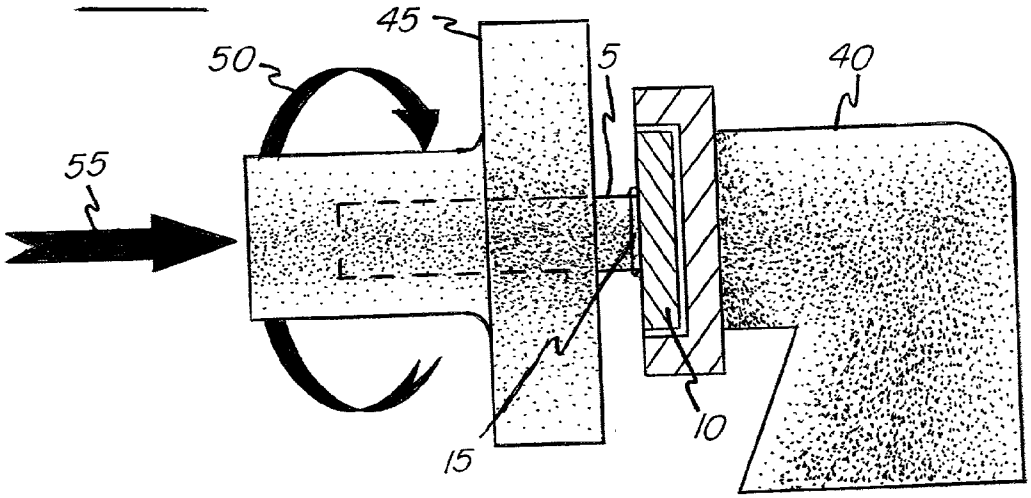
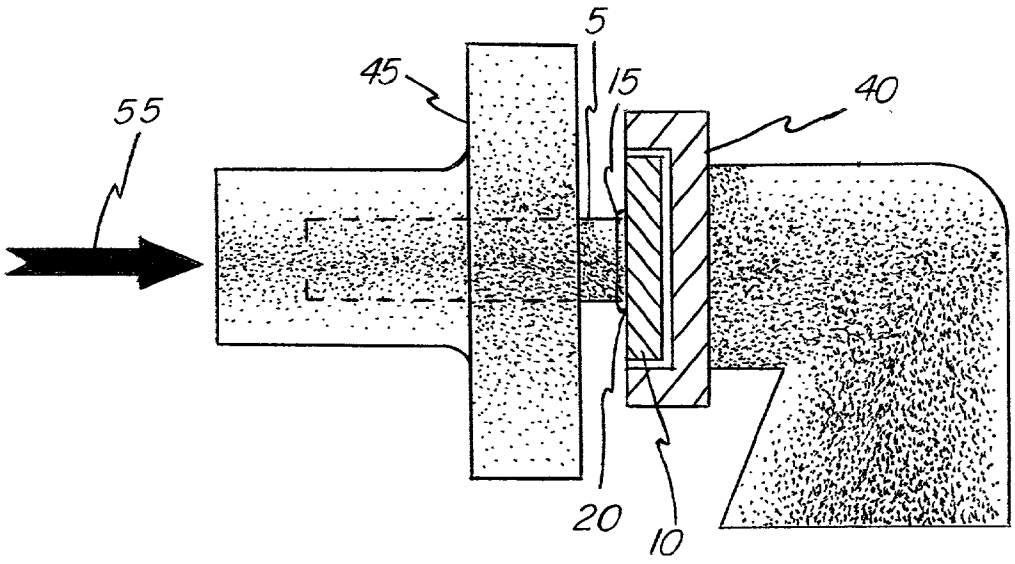


FIG - 7



END ANCHORS

BACKGROUND OF THE INVENTION

[0001] The present invention relates to structural reinforcement bars including integral end anchors, as used in poured concrete construction, and to methods of manufacturing such structural reinforcement bars. A structural reinforcement bar, or "rebar," essentially comprises a cylindrical body, which may include ribs for impeding turning and axial displacement when the bar is embedded in concrete. For example, such a rebar may have a series of axially spaced-apart, annularly extending ribs and at least one axially extending continuous rib. Alternatively, helical or oblique annular ribs may be used to impede turning and axial pullout. These rebars are generally made of steel and are often used as structural reinforcing elements in concrete structures.

[0002] Quite often the need arises for such rebars to incorporate, at least on one end, a means to increase the associated axial pullout strength. This is particularly the case when concrete formwork is massive, or is carried out in steps or stages, such that the given structural rebar extends between different parts of the concrete structure. In many of such cases, the rebar is exposed to axial forces close to its ultimate tensile strength. In many additional cases, the given reinforcement bar is only partially embedded in concrete with its exposed end equipped with an attachment means. Depending upon the anticipated axial tension imposed by the attached load and the length of embedment, use of means to increase the associated reinforcement bar axial pullout performance may be required.

[0003] One known end anchoring method requires formation of a hook in the end of the rebar which is to be exposed to high axial tension. A second perpendicularly extending rebar is inserted through the hook of the first rebar. The resulting axial pullout strength of the first rebar is increased to the extent that either the hook will straighten or the perpendicularly extending rebar is pulled laterally from its embedment. In either event, this known end anchoring method, while typically satisfactory as far as axial pullout performance is concerned, is impractical in space limited construction. Large diameter hooked rebar in narrow structural concrete members presents particularly difficult construction problems. Rebar congestion, poor concrete consolidation, higher concrete placement costs and poor in-place concrete quality are all concerns when employing large diameter hooked rebar in confined structural members.

[0004] A second known end anchoring method employs a structural reinforcement bar with an enlarged head which is formed on at least one end of the rebar through forging. This known anchoring method, while satisfactory as far as space related constraints are concerned, often lacks the requisite tensile strength in the transition area between the rebar and forged head. A larger size rebar is typically required to overcome the reduced tensile strength in the transition area, thereby increasing construction costs.

SUMMARY OF THE INVENTION

[0005] It is an object of the present invention to provide a structural reinforcement bar with improved axial tensile strength and pullout performance for use in poured concrete construction. It is a further object of the present invention to provide a structural reinforcement bar applicable in limited space construction.

[0006] In accordance with a preferred embodiment of the present invention, an anchorage plate is fixed to the end of a rebar body through friction welding and, more preferably, through inertia welding. The heat for friction welding and inertia welding comes from mechanical friction between two abutting pieces of material that are held together while one rotates and the other remains stationary. For best weld performance, abutting surfaces at the ends of the workpieces are cut accurately and are substantially smooth.

[0007] In the friction welding process, the moving part (the body in the present invention) is held in a rotationally driven collet while the stationary part (the anchorage plate in the present invention) is held against it in a stationary collet at a selected level of axially imposed pressure. Friction quickly generates enough heat to raise the abutting surfaces to the desired welding temperature. As soon as the desired welding temperature is reached, rotation is stopped and the pressure is maintained or increased to complete the weld.

[0008] In inertia type friction welding the rotationally driven collet is attached to a rotating flywheel. The flywheel is brought to a specified rotational speed and is then separated from the corresponding rotational force. The rotating assembly is then pressed against the stationary member and the kinetic energy of the flywheel is converted into frictional heat. The weld is formed as the flywheel stops its motion and the pieces remain pressed together. Since grain size is refined during hot working, the strength of the friction weld is substantially the same as that of the base metal.

[0009] In a preferred embodiment of the present invention, the end of the rebar which is to be fixed to the anchorage plate is forged to form an enlarged boss prior to the friction welding or inertia welding. Providing an enlarged weld boss, in combination with friction welding or inertia welding, provides a weld strength which substantially matches, or exceeds, the tensile strength of the given rebar.

[0010] In both friction welding and inertia welding, the total cycle time to produce a weld is usually less than 25 seconds, while the actual time of heating and welding is about 2 seconds. Because of the short periods of heating and the limited time for heat to flow away from the joint, the weld and heat affected zones are very narrow. Surface impurities on the joint faces tend to be displaced radially into a small upset flash that can be removed after welding if desired. Because virtually all of the energy is converted to heat, the process is very efficient, and it can be used to join many metals or combinations of dissimilar metals. Friction and inertia welding methods, such as those disclosed herein, produce extremely repeatable conditions (consistent welds) and can be readily automated.

[0011] The basic anchorage method in accordance with the present invention is designed around an integral friction, or inertia, welded rebar and anchorage plate. The end of the rebar that is attached to an anchorage plate may be essentially constant in diameter or enlarged by upset forging prior to friction or inertia welding the end to the anchorage plate. The reinforcement bar splicing and coupling means as disclosed in U.S. Pat. Nos. 4,619,096 and 5,152,118, and as incorporated herein by reference, may be fixed to the rebar

on the end opposite the anchorage plate. Thereby, the basic structural reinforcement bar with integral anchorage plate in accordance with the present invention may be supplied in various configurations by employing an appropriate end opposite the anchorage plate end (i.e., a second anchorage plate, a plain end, an internally threaded female socket or an externally threaded male engagement) to satisfy numerous application requirements. The structural reinforcement bar in accordance with the present invention may also be used in connection with various reinforcement bar splicing and coupling means in situations where the installation sequence, or other restrictions, mandate the efficient use of space.

[0012] Other objects and advantages of the invention will be apparent from the following description, the accompanying drawings and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] **FIG. 1** is a partial cross-sectional view illustrating structural reinforcement bars, in accordance with the present invention, embedded in poured concrete, wherein the conical shaped shaded areas extending from the anchorage plates represent the distribution of forces associated with the reinforcement bar and anchorage plate;

[0014] **FIG. 2** is a partial side elevational view of one embodiment of a structural reinforcement bar in accordance with the present invention;

[0015] **FIG. 3** is a cross-sectional view, taken along line **3-3** of **FIG. 2**, illustrating the relative diameters of the rebar, the weld boss and the anchorage plate;

[0016] **FIG. 4** is a view similar to **FIG. 2** of a second embodiment in accordance with the present invention;

[0017] **FIG. 5** is a side elevational view, in partial schematic, illustrating a rebar inserted in a rotationally driven collet with a rotational force applied and an anchorage plate inserted in a stationary collet prior to engagement;

[0018] **FIG. 6** is a side elevational view, in partial schematic, illustrating a rebar inserted in a rotationally driven collet with a rotational force applied and an anchorage plate inserted in a stationary collet with an axial force applied; and

[0019] **FIG. 7** is a side elevational view, in partial schematic, illustrating a rebar inserted in a rotationally driven collet and an anchorage plate inserted in a stationary collet after application of the axial force.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0020] With reference to **FIG. 1**, there is shown a plurality of structural reinforcement bars **2** embedded in a poured concrete structure **4**. At least some of the structural reinforcement bars **2** include a cylindrical body **5** connected to an anchorage plate **10**. The body **5** is of a nominal diameter and includes raised ribbing **6** extending thereacross between opposing first and second rebar ends **7** and **8**.

[0021] In a first preferred embodiment of the present invention, as depicted in **FIGS. 2 and 3**, the anchorage plate **10** is fixed to the body **5** by friction welding, which may comprise inertia welding, the weld being shown at **15**. As can be seen from **FIG. 3**, it is the circumference of weld **15** which defines the area associated with abutting surface **20**. The weld **15** is formed during the friction or inertia welding process as described herein with regard to the method of manufacturing a structural reinforcement bar in accordance with the present invention.

[0022] A second preferred embodiment, as seen in **FIG. 4** of the drawings, utilizes a rebar **16** on which the end **17** to be attached to an anchorage plate **18** is first enlarged by upset forging or the like prior to forming the weld **19** by friction or inertia welding to join the enlarged end to the anchorage plate **18**.

[0023] In both embodiments it should be noted, a rebar, whether smooth, or as shown, deformed, is welded to a lower strength anchorage plate, whether square, round or other shape, and superior axial pullout strength is achieved.

[0024] The conically shaped shaded areas **25**, shown in **FIG. 1** as extending from the anchorage plates **10**, reflect the distribution of force within the poured concrete structure **4** with relation to the structural reinforcement bar **2**. As can be seen from **FIG. 1**, the forces associated with the anchorage plate **10** which are transferred to the rebar **5** are concentrated where the rebar **5** is connected to the anchorage plate **10** at abutting surface **20**. Inertia and friction welding provides a cohesive bond across the entire area of the abutting surface **20**, which is equivalent to the cross-sectional area of the weld **15**.

[0025] As shown additionally in **FIG. 1**, the structural reinforcement bar **2** in accordance with the present invention may be equipped with an internally threaded female socket **30** or an externally threaded male engagement **35** on the second end **8** of rebar **5** opposite the end of rebar **5** with anchorage plate **10**. The addition of the socket **30** or threaded male engagement **35** to the structural reinforcement bar **2** enhances the applicability to confined space construction. Alternatively, in accordance with the present invention, the structural reinforcement bar **2** may incorporate a second anchorage plate **10** on the second end **8** of rebar **5**.

[0026] It should be understood that the splicing and coupling means such as those disclosed in U.S. Pat. Nos. 4,619,096 and 5,152,118 may be fixed to the structural reinforcement bar **2** in accordance with the present invention through friction welding or inertia welding. In such an event, the internally threaded female socket **30** or the externally threaded male engagement **35** would be formed prior to attachment to the body **5**.

[0027] Referring to FIGS. **5-7**, the method of the present invention is illustrated. A stationary collet **40** is horizontally aligned with a rotationally driven collet **45**. The structural reinforcement bar **2** in accordance with the present invention is manufactured utilizing collets **40** and **45** such as those depicted in FIGS. **5-7** to facilitate the inertia, or the friction, welding process.

[0028] The anchorage plate **10** is inserted in the stationary collet **40** and the body **5** is inserted in the rotationally driven collet **45**. A rotational force **50** is applied to the rotationally driven collet **45** until a predetermined desired rotational speed is reached. Next, the rotational force **50** is removed from the rotationally driven collet **45**. An axial force **55** is then applied to the rotationally driven collet **45** to bring the end of the body **5** into contact with the anchorage plate **10**.

The axial force **55** is maintained, or alternatively increased, until the rotationally driven collet **45** stops rotating and the body **5** is fixed to anchorage plate **10** at the weld **15**. The completed structural reinforcement bar **2** is then removed from the collets **40** and **45**.

[**0029**] In an alternative embodiment of the present invention, the anchorage plate **10** is fixed to the rebar **5** by friction welding. The friction welding process differs from the above described inertia welding process in that the rotational force **50** remains applied to rotationally driven collet **45** until after the axial force **55** has been applied and the desired weld temperature is achieved. After achieving the desired weld temperature, the rotational force **50** is removed.

[**0030**] With a complete range of structural reinforcement bars **2** in various configurations, design engineers, contractors and fabricators may rely on this simple and economical replacement for hooked and shaped rebar to ease congestion, concrete placement and to overcome axial pullout constraints. The structural reinforcement bar's bond development strength and the mechanical bearing interlock of the anchorage plate **10**, surrounded by consolidated concrete, increases dependability, reliability and confidence in resulting end anchorage embodiments. Anchorage tests have shown that structural reinforcement bars **2**, in accordance with the present invention, may be embedded as little as eight to twelve bar diameters and achieve full axial tensile strength provided there are no boundary conditions, such as, inadequate concrete cover, lack of edge distance or local flexure to affect the anchor's ductile behavior.

[**0031**] The inertia or friction welded structural reinforcement bar **2** in accordance with the present invention improves the axial pullout performance over that of comparable anchorage systems. The structural reinforcement bar **2** in accordance with the present invention, in addition to use as structural reinforcement in poured concrete construction, can be utilized very effectively for end anchorages, stirrup replacements, and anchorage for light standards, posts and signage.

[**0032**] While the form of apparatus herein described constitutes a preferred embodiment of this invention, it is to be understood that the invention is not limited to this precise form of apparatus, and that changes may be made therein without departing from the scope of the invention which is defined in the appended claims.

What is claimed is:

1. In a reinforced concrete construction comprising a concrete structure and a reinforcing bar embedded therein; the improvement comprising;

an anchorage plate, and

a friction weld joining a surface of said anchorage plate to an end of said reinforcing bar.

2. The construction of claim 1 wherein said friction weld is an inertia weld.

3. The construction of claim 1 wherein said end of said reinforcing bar is enlarged.

4. The construction of claim 3 wherein said end of said reinforcing bar is enlarged by upset forging.

5. The construction of claim 1 wherein said anchorage plate is of lower strength than said reinforcing bar.

6. The construction of claim 1 wherein said anchorage plate is round.

7. A reinforced concrete construction comprising a concrete structure, at least one reinforcing bar embedded in said concrete structure, said reinforcing bar having an end thereof enlarged by upset forging, a substantially round anchorage plate of lower strength than said reinforcing bar and a friction weld joining said enlarged end of said reinforcing bar to a surface of said anchorage plate.

8. A method of manufacturing a structural reinforcement bar for embedding in poured concrete construction of the type having a rebar body extending between opposing first and second ends, comprising the steps of:

providing an anchorage plate;

inserting one of said anchorage plate and said body in a stationary collet;

inserting the other of said body and said anchorage plate in a rotationally driven collet with said first end of said body oriented toward said anchorage plate;

applying a rotational force to said rotationally driven collet until a desired rotational speed is reached;

applying an axial force to bring said first end of said body into contact with said anchorage plate;

removing said rotational force from said rotationally driven collet;

maintaining said axial force until said rotationally driven collet stops rotating and said body is fixed to said anchorage plate; and

removing said body and said anchorage plate from said driven collet and said stationary collet.

9. A method of manufacturing for embedding in poured concrete construction a structural reinforcement bar of the type having a rebar body extending between opposing first and second ends, comprising the steps of:

forming an enlargement on a first end of a rebar body;

providing an anchorage plate;

inserting one of said anchorage plate and said body in a stationary collet;

inserting the other of said body and said anchorage plate in a rotationally driven collet with said enlarged end oriented toward said anchorage plate;

applying a rotational force to said rotationally driven collet until a desired rotational speed is reached;

removing said rotational force from said rotationally driven collet;

applying an axial force to bring said first end into contact with said anchorage plate;

maintaining said axial force until said rotationally driven collet stops rotating and said body is fixed to said anchorage plate; and

removing said body and said anchorage plate from said driven collet and said stationary collet.

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