Sept. 12, 1967 F. D. REILAND 3,340,667

CONCRETE STRUCTURE WITH COMBINATION COMPRESSION AND TENSION REINFORCEMENT SPLICES

Filed Jan. 13, 1964 5 Sheets-Sheet 1

Fig. 1.

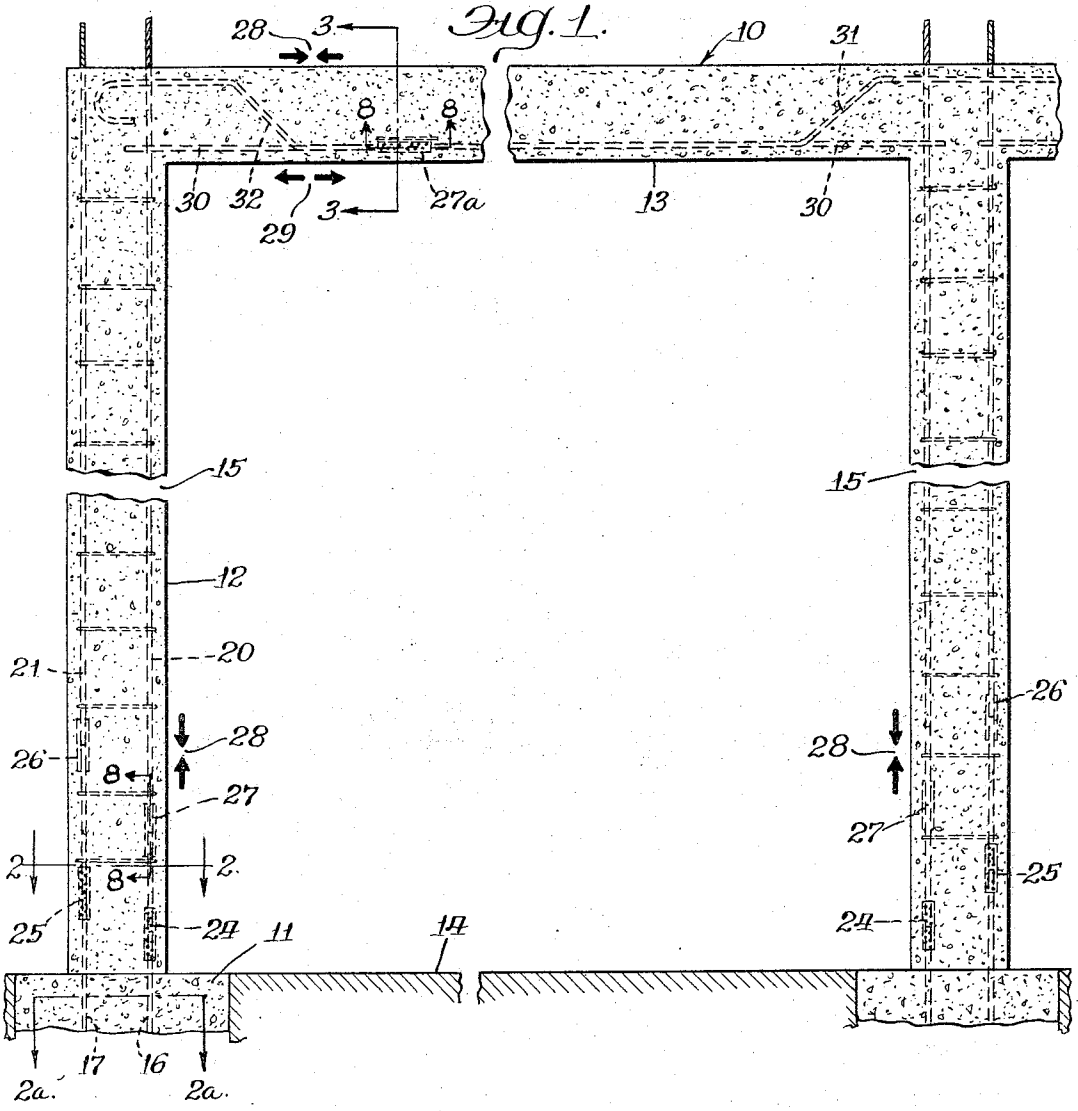


Fig. 2

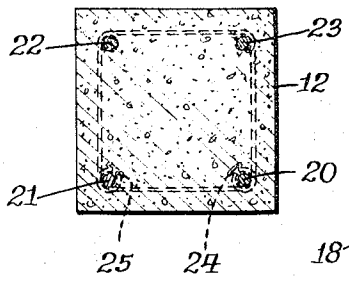


Fig. 2a

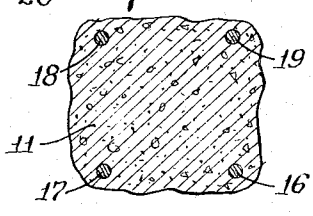
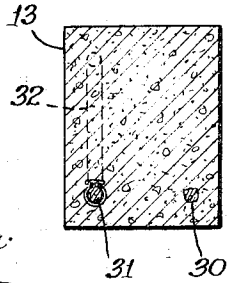


Fig. 3.



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Fig. 4.

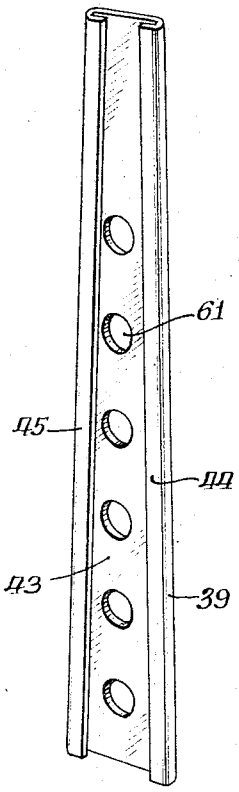


Fig. 5.

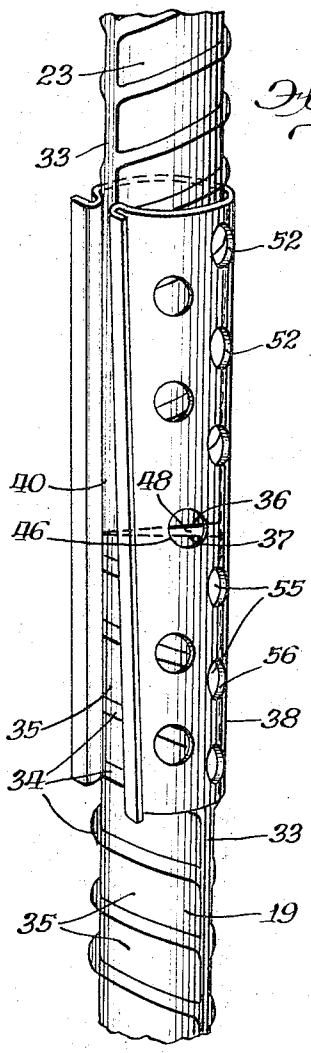


Fig. 6.

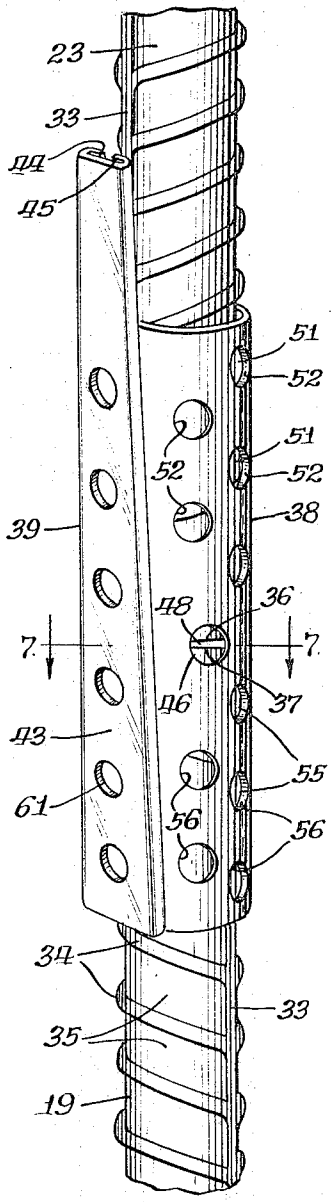
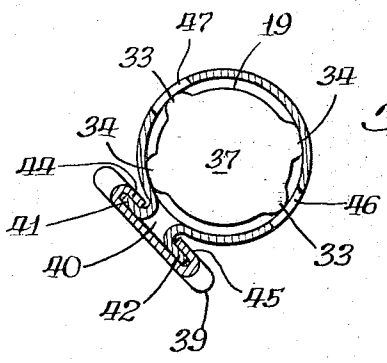


Fig. 7.



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CONCRETE STRUCTURE WITH COMBINATION COMPRESSION AND TENSION REINFORCEMENT SPLICES
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Fig. 8.

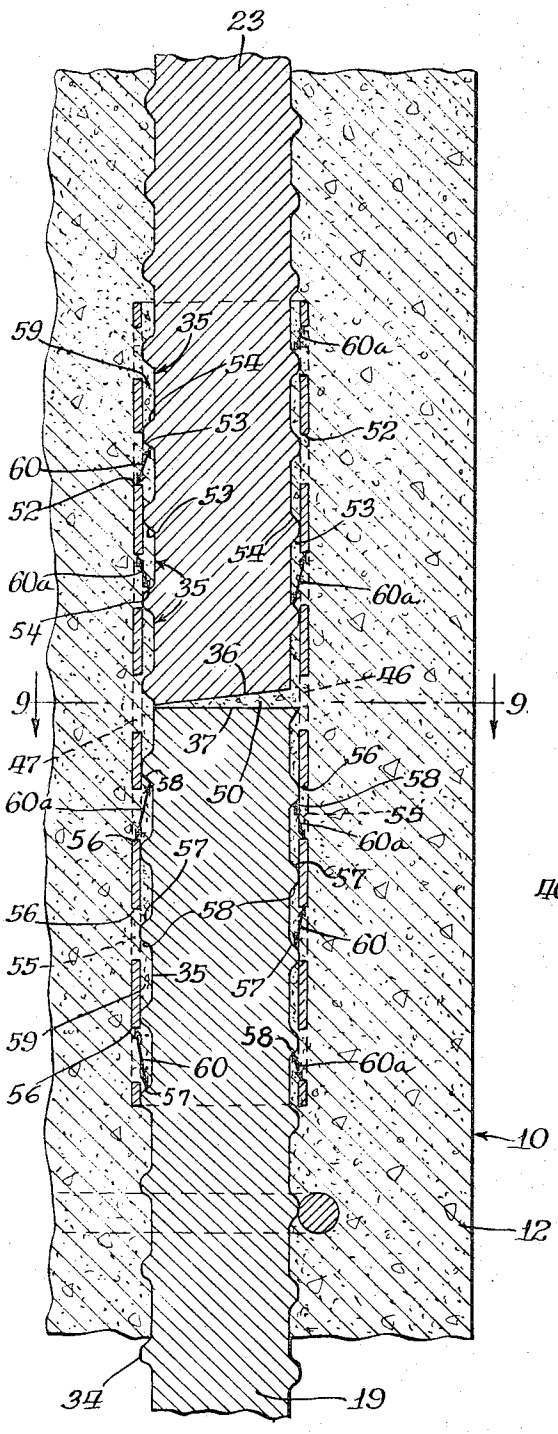
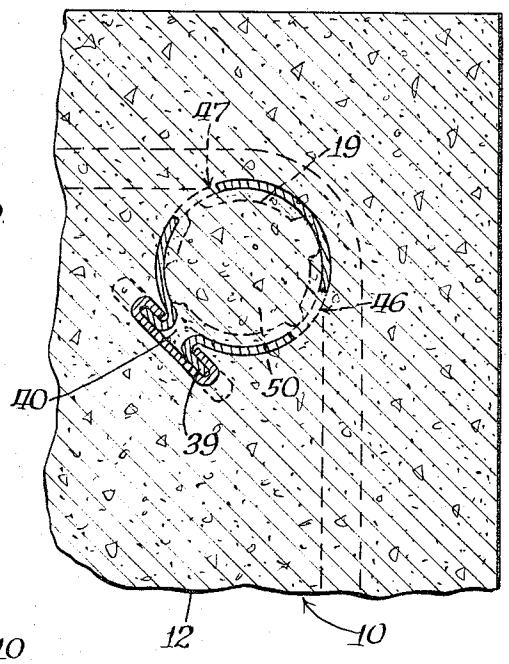


Fig. 9.



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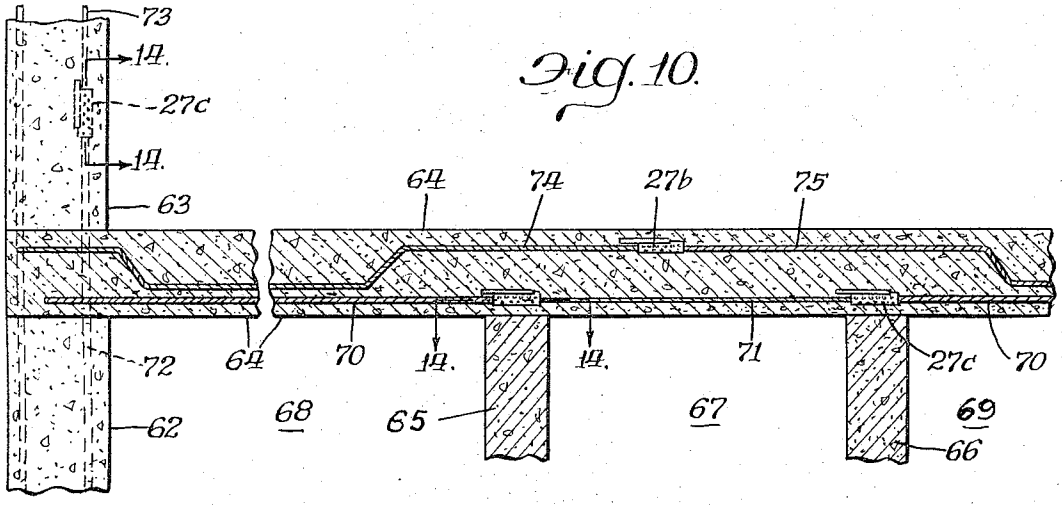


Fig. 10.

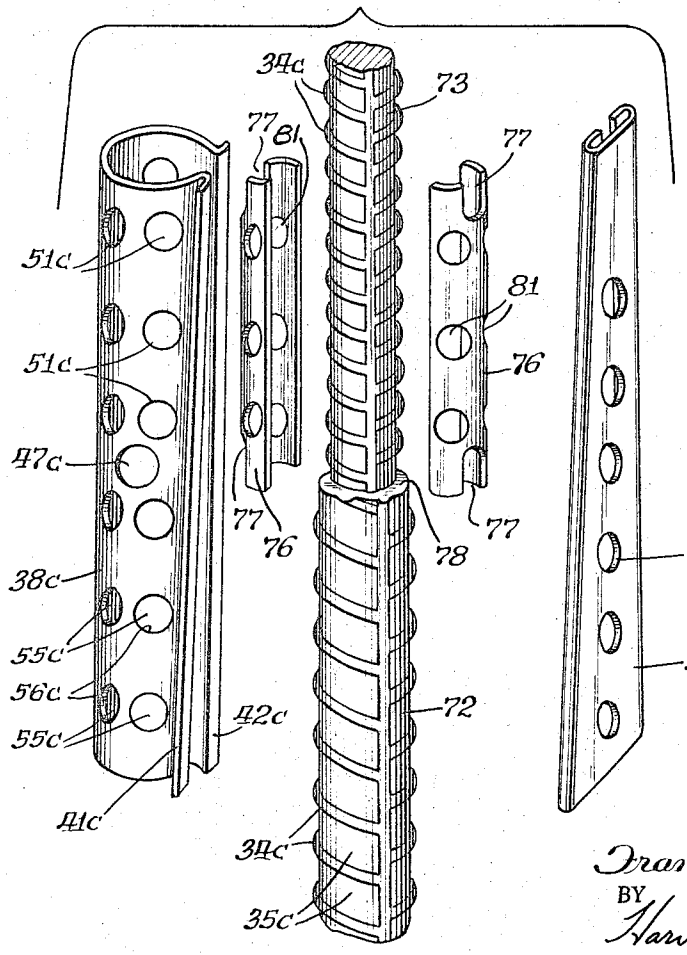


Fig. 11.

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CONCRETE STRUCTURE WITH COMBINATION COMPRESSION AND TENSION REINFORCEMENT SPLICES

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Fig. 12.

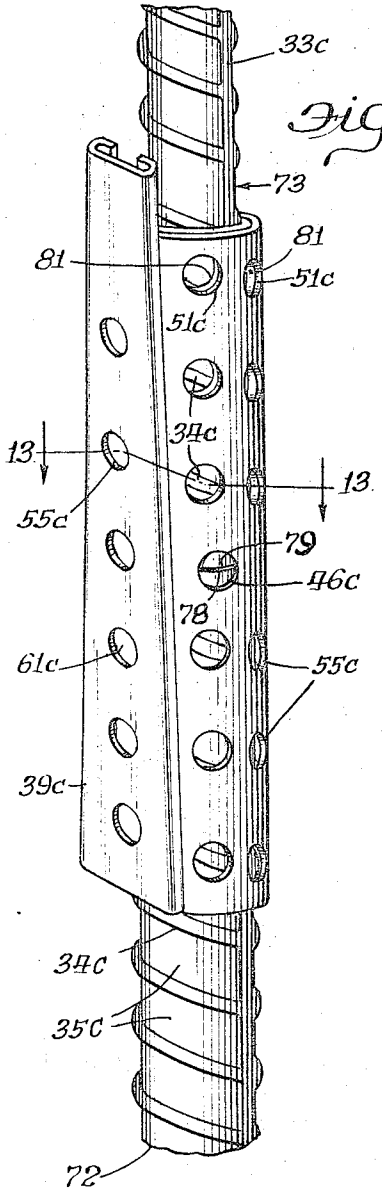


Fig. 14.

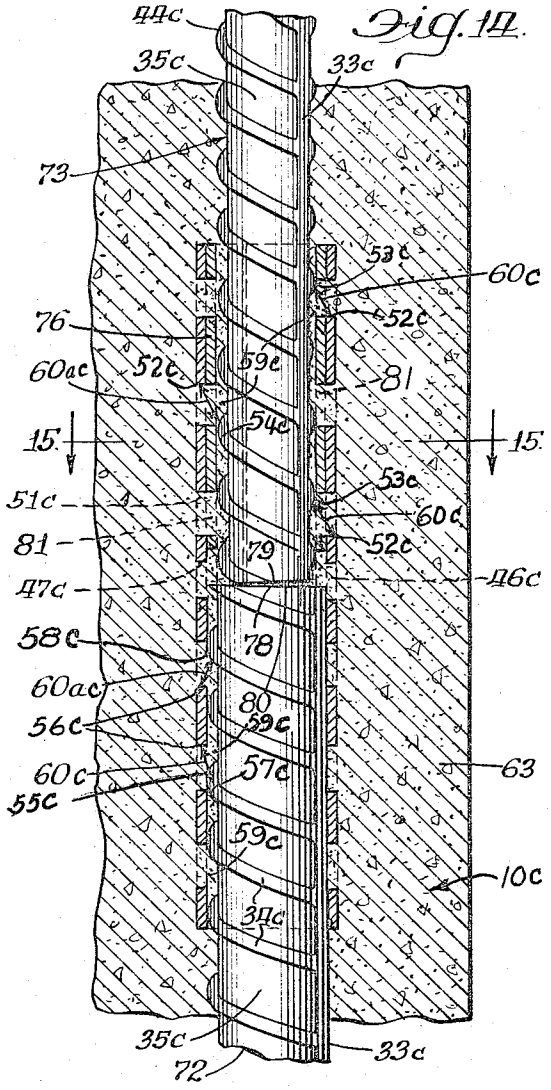


Fig. 15.

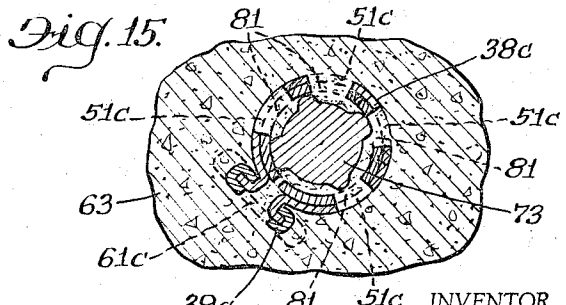
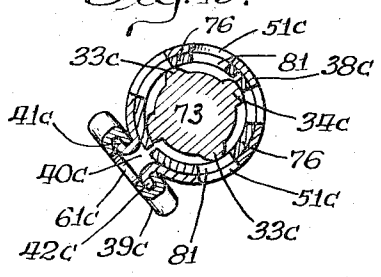


Fig. 13.



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United States Patent Office

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CONCRETE STRUCTURE WITH COMBINATION COMPRESSION AND TENSION REINFORCEMENT SPLICES

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Filed Jan. 13, 1964, Ser. No. 337,200
The portion of the term of the patent subsequent to Apr. 12, 1983, has been disclaimed
5 Claims. (Cl. 52—722)

The present invention relates to an improved reinforced concrete structure. This application is a continuation-in-part of application Ser. No. 321,947 filed Nov. 6, 1963, now abandoned, which was a continuation-in-part of application Ser. No. 200,204, now Patent No. 3,245,190; the present application is also a continuation-in-part of application Ser. No. 208,714, now Patent No. 3,245,189.

The principal object of the invention is to provide, in a concrete structure, a reinforcement comprising at least two deformed reinforcing bars spliced together in endwise abutting relation by means of a splice structure which is so formed as to function, in cooperation with the concrete per se and with the deformations on the bars, to provide multiple interlocks between said deformations and parts of the splice structure, which interlocks develop, at the splice, increased load supporting strength in compression and increased yield strength in tension.

A further object of the invention is to provide, in a reinforced concrete structure of the above character, a splice structure that clamps the bars so as to maintain them in endwise abutting relation prior to the pouring of the concrete and before the formation of said interlocks.

A further object is to provide, in a concrete structure of the above character, a sleeve splice provided with a plurality of openings of suitable size to permit the concrete grout to flow freely into the sleeve and to form therein appendant segments of the main concrete body which fill channel-like voids between the deformation ribs of the bars and the space between the end faces of the bars, whereby these appendant bodies of concrete, being confined with the splice structure and being subjected to triaxial loading, provide strong interlocking concrete bodies for developing increased yield strength in tension at the splice and also provided maximum strength in compression, even though the end faces of the bars are not in total contact with each other.

According to the invention, at least one pair of conventionally deformed reinforcing bars are spliced together in end-to-end alignment and embedded in a concrete body to reinforce the same. The concrete body may be of various forms, for example columns, beams, joist, or flooring of a building structure, storage dams, foundations and/or any other reinforced concrete structure which normally requires metallic reinforcement.

The splice reinforcing bars may be positioned either vertically or horizontally in the concrete body, since the splice structure has capacity for developing resistance strength against both compressive and tensional forces which may be present in such concrete body. In this connection the improved splice means includes a sleeve structure for embracing the adjacent end portions of the spliced bars, including a series of the conventional deformation ribs formed thereon and the channels intervening between adjacent deformation ribs.

The adjacent end faces of the bars may be square cut or substantially square cut, that is to say, a slight relative inclination of the end faces is permitted, since provision is made under the present invention for filling and clearance space between the end faces of the bars with a body of concrete grout. The hardened grout body, being enclosed in the metallic sleeve and surrounded by a substantial thickness of hardened concrete, becomes triaxially loaded under compressive forces and therefore constitute a non-compressible body of concrete connected, as an appendage, to the main concrete body.

The sleeve structure of the splice is perforated throughout with openings of substantial size defining passageways for admitting concrete grout into the space between the end faces of the bars and into the channels between the deformation ribs on the bars. The bodies of concrete grout in said channels abut against the side walls of the said channels and against the perimeter surfaces of the passageway openings in the sleeve structure to provide key-like interlocks for resisting compressive and tensional stresses imposed on the splice structure.

The invention is illustrated in certain preferred embodiments in the accompanying drawings wherein:

FIG. 1 is a side view in elevation of a concrete structure in which metallic reinforcements are embedded in regions of the concrete to resist both compressive and tensional forces;

FIG. 2 is a cross-sectional view taken on line 2—2 of FIG. 1;

FIG. 2*a* is a fragmentary cross-section taken on line 2*a*—2*a* of FIG. 1;

FIG. 3 is a cross-sectional view taken on line 3—3 of FIG. 1;

FIG. 4 is a view in perspective of a wedge member forming a part of the splice structure for connecting a pair of reinforcing bars;

FIG. 5 is a view in perspective of a split sleeve element embracing the adjacent ends of a pair of reinforcing bars;

FIG. 6 is a perspective view showing the sleeve structure of the invention assembled in its operative clamping position about the adjacent ends of a pair of reinforcing bars;

FIG. 7 is a cross-sectional view taken on line 7—7 of FIG. 6;

FIG. 8 is a longitudinal section through either the vertical or horizontal splice structures shown in FIG. 1;

FIG. 9 is a fragmentary cross-section through a concrete body and through a reinforcement splice embedded therein, the section being taken on line 9—9 of FIG. 8;

FIG. 10 is a fragmentary view in elevation of a concrete structure provided with a metallic reinforcement comprising conventionally deformed bars of different size classifications spliced in end-to-end relation;

FIG. 11 is a perspective view of two bar sections of different diameters arranged in end-to-end relation and showing also the several elements of a clamp structure for splicing the said bars together;

FIG. 12 is a perspective view showing the clamp elements of FIG. 11 assembled in clamping relation about two bars of different diameters;

FIG. 13 is a cross-sectional view taken on line 13—13 of FIG. 12;

FIG. 14 is a longitudinal section similar to FIG. 8, but illustrating the clamp structure of FIGS. 11–13; and

FIG. 15 is a cross-section taken on line **15—15** of FIG. 14.

Referring first to FIGS. 1 to 9, inclusive of the drawings: **10** designates a reinforced concrete body in the form of a structure of a building. It comprises foundation pier **11**, vertical column **12** supported on the piers, and a horizontal girder **13** for connectiing the upper ends of the column **12** and other verticals (not shown) in the structure. Column **12** is subjected principally to the compressive stresses because of the compression load imposed lengthwise thereon, and the girder **13** and the other horizontal members (not shown) in the structure are subjected principally to tensional stresses incident to the load imposed transversely thereon. The building structure, therefore, presents an apt structure for illustrating compressive and tensional stresses, both of which are resisted by the present invention. However, the building structure shown is intended as an illustration only and not as a limitation.

The foundation pier **11** may extend to any suitable depth below the floor level **14** of the building, and the girder **13**, since the columns are broken away as indicated at **15**, may be treated as being associated with either the second or third floor of the building. In any event the reinforcement bars embedded in the column **12** are of lengths sufficient to project above the upper floor level and to which additional bars (not shown) may be spliced to extend the height of the building.

Referring now to the metallic reinforcement for the column **12**: Inasmuch as the reinforcements for the columns in FIG. 1 are identical, it will be sufficient to describe the reinforcement of the pier **11** and the column **12** at the left of FIG. 1. This reinforcement may include any desired number of pairs of conventionally formed bars, for example four pairs arranged in vertical alignment. The lower bars are members **16, 17, 18** and **19** (see FIGS. 1 and 2*a*). Each bar may be of any suitable length, depending upon the amount of reinforcement required, and the bars are embedded in spaced relation in the pier **11**. The upper ends of the lower bars **16, 17, 18** and **19** extend different distances above the pier **11** and are connected, respectively, to the lower ends of upper bars **20, 21, 22** and **23** by means of like splices **24, 25, 26** and **27** (see FIGS. 1 and 2). Inasmuch as the upper ends of the bars **16, 17, 18** and **19** terminate at different distances above the pier **11**, the splice structures **24, 25, 26** and **27** are located in staggered relation and thereby provide continuity of the reinforcement throughout the length of the column and also prevent excessive displacement of concrete at a single location transversely of the column.

A vertical column, such as the column **12**, is defined primarily to support the compressive loads represented by the arrows **28** in FIG. 1. Nevertheless, there are some tensional stresses present therein from time to time, for example during severe wind pressures. Therefore the present splice structure is highly desirable for use in columns, since it is designed not only to support compressive loads, but also resists tensional stresses.

The horizontal members of a building, for example, the girders **13**, are subjected primarily to tensional stresses since the load is normally applied transversely thereof in the direction of gravity. For convenience of illustration the arrows **29** are intended to represent tensional stresses in the girder. Accordingly the metallic reinforcements herein indicated as bar sections **30, 31** and **32**, are embedded in the girder to extend lengthwise thereof below its center of gravity and preferably in the region of greatest tensional stress near the lower face of the girder. The bar **30** may be of sufficient length to extend across the entire span between the column **12**, but the bar sections **31, 32** are butt spliced together by means of sleeve splice structure **27***a*. The construction of the splice structure **27***a* conforms identically with the structure of the compression splice structures **27** embedded in the column **12**. However, when the splice structure **27***a* is embedded in a horizontal position, such as herein illustrated, it functions primarily to provide yield strength for resisting tensional stresses.

Inasmuch as the tension resisting capacity of the sleeve splice **27***a* depends upon its special cooperation with the deformations on the reinforcing bars, and in view also of the fact that the sleeve splice **27** cooperates with the deformations to increase its strength in compression, the bars will be described briefly before the description of the sleeve structure of the splice means.

There are various designs of deformed reinforcing bars, but generally they include a pair of ribs **33**, one rib at either side of the bar extending the entire length of the bar (see FIGS. 5 and 6). A series of transverse ribs **34** on opposite sides of the bar are spliced apart lengthwise thereof with their ends terminating at or near the longitudinal ribs **33**. It will be observed that each pair of the transverse ribs **34**, defines an intervening channel **35**. The longitudinal and transverse ribs define the perimeter of the bar which is gripped, as hereinafter described, by the sleeve structure to move the bar ends into axial alignment and to maintain them in this position during the pouring of the concrete to form the concrete body **10**.

The adjacent end faces of the bars, particularly the vertical bars in the columns **12, 12**, are preferably, though not necessarily, cut sufficiently square to insure coplanar contact. However, if the end faces of the bars are reasonably square as they come from the mill no additional cutting is required, since the improved structure of the present invention makes it possible to splice bars having end faces **36, 37** (FIG. 5) inclined relative to each other or otherwise spaced apart within an allowable clearance tolerance.

Referring now to the construction and operation of the sleeve splice structure: All sleeve splice structures shown in FIG. 1 of the drawings have identical constructions and comprise in each case a sleeve element which embraces the adjacent end portions of both bars being spliced, for example the bars **19** and **23**. Considered in its broadest aspect the sleeve may be of any suitable form and construction to insure its interlocking cooperation, hereinafter described, with the bars and the concrete body per se, whereby it develops increased load supporting strength in compression and also develops increased yield strength in tension. However, the preferred specific construction of sleeve structure comprises a split sleeve element **38** and a cooperating wedge member **39** (see FIGS. 4, 5, 6 and 7). The edges of the sleeve along the slit **40** are turned laterally in opposite directions to form wedge-like flanges **41, 42**. The wedge member **39** is a unitary structure slightly longer than the sleeve element **38**. It comprises a flat plate **43** having diverging edges which are bent inwardly to provide hook-shaped flanges **44–45** for interlocking engagement with substantially the entire length of the outturned flanges **41–42** of the sleeve, as shown best in FIGS. 7 and 9 of the drawings. The diameter of the sleeve element **38** is slightly larger than the diameters of the butted bar ends and is sufficiently flexible to yield circumferentially. The function of the wedge is to draw the flexible side walls of the sleeve in a wrap-around constrictive fashion into tight gripping engagement with the perimeters of the end portions of the bars being spliced.

The sleeve **38** being, as previously indicated, slightly larger in diameter than the butted bar ends, may be slipped over one of the bars and moved to a position clear of its end so as to facilitate installation of the other bar. After the bars are brought into partial alignment, the sleeve may be positioned to overlap both bars and the flanges **44, 45** of the wedge **39** are interlocked with the flanges **41, 42** of the sleeve **38**. During the initial driving of the wedge, the sleeve may be held by any suitable clamp (not shown) in its proper centralized position relative to the faces **36, 37** of the butted bar ends until the sleeve is contracted into initial gripping engagement with the perimeters of the bars, the perimeter being defined by the transverse ribs **34** and the vertical ribs **33**. After the initial constric-

tive gripping contact on either or both of the butted bar ends the area of the contact together with the constrictive pressure asserted is sufficient to maintain the sleeve in its proper position during the further driving of the wedge to increase the grip of the device on the bars.

The constricting clamping action of the sleeve **38** on the end portions of the bars being spliced (for example bars **19** and **23**, FIGS. 1 and 5, or bars **31–32**, FIG. 1) automatically effects axial centering thereof. The circumferential flexibility of the sleeve facilities conforming of the sleeve in a manner to compensate for tolerance variations in the perimeter contours of the bars. The circumferential flexibility of the sleeve together with the slight tension of the sleeve walls and parts of the wedge permits the sleeve to yield sufficiently to conform to normal tolerance variations in the respective diameters of the bars. This adaptability of the sleeve **38** and its wedge **39** to compensate for tolerance variations in the diameters of the respective bars is evidenced by the fact that if the bars vary slightly in their respective diameters the sleeve will first grip the bar of larger diameter and thereafter upon further driving the wedge downwardly will grip the bar of slightly smaller diameter.

When the sleeve is in its proper position a pair of diametrically opposed apertures **46–47** formed in the side of the sleeve will be so positioned as to communicate with the space **48** existing between the end faces **36–37** of the butted bars (see FIGS. 5–7). It will be observed in this connection that the sleeve element tightly grips the perimeter of the splice bars and therefore closes the space between the end faces of the bars except for the openings **36–37** and the opening **40** formed by its split wall. Consequently a body **50** of relatively fine concrete grout enters into the space **48** and therefore is confined in a substantially closed metallic chamber surrounded by a thick band of concrete constituting part of the main concrete body **10** (FIG. 8). Upon hardening of the internal body **50** of concrete grout and the hardening of the external body **10** of concrete, the internal body **50** is rendered non-compressible and non-displaceable relative to the bar ends **36, 37**. In addition to transmitting compressive forces uniformly across the entire areas of the end faces **36, 37** of the spliced bars, the grout body **50** imparts to the splice structure a compressive strength capacity equal to or greater than the ultimate compressive strength capacity of a reinforced concrete body similar to the column **12** but reinforced with non-spliced reinforcing bars of the same size and quality embedded in the structure herein shown.

The sleeve element **38** is provided with two groups of additional apertures arranged in closely spaced relation throughout the length and circumference of the sleeve. One group is formed in the portion of the sleeve embracing the bar **23** and is designated by reference numerals **51**. The surface defining the perimeter of each of the above apertures is designated **52** and constitutes in each case a diametrically extending abutment surface adapted to cooperate with one or the other side face **53** or **54** of an adjacent channel **35** of the bar **23** when the latter is filled with concrete as hereinafter described. The portion of the sleeve **38** containing the second group of apertures embraces the end of the bar **19** and is designated **55**. The surfaces defining the perimeters of the apertures constitute diametrically extending abutment surfaces **56** adapted to cooperate with the side walls **57–58** of adjacent channels **35** in the end portion of the bar **19** to complete the transmission of stresses to or from the bar **23**.

The apertures **51** and **55**, in addition increasing the flexibility of the sleeve **38**, constitute passageways through which concrete grout, during the formation of the columns **12** and girder **13**, flows into the sleeve to fill the channels **35** of both bar ends embraced by the sleeve. Upon hardening of the concrete, the hardened grout within said channels **35**, being confined within the sleeve **38** and being also surrounded by a heavy band of hardened concrete in the main body **10**, constitutes a series of appendant non-compressible segments **59** of the main concrete body. These segments function as key-like interlocks to transmit compressive and/or tensional stresses from one or the other of the bars **19–23** to the sleeve **38** and thence to the other one of the bars, depending of course upon whether the sleeve structure is being used as a compression or a tension splice.

When the sleeve structure is used as a compression splice, the line of compressive force leads from the abutment face **53** on bar **23** through a concrete interlock **59** to an opposed abutment surface **52** (the perimeter of an aperture **51**) as indicated by the arrows **60** in FIG. 8 and thence through the sleeve **38** to the perimeter **56** of an aperture **55** serving as an abutment surface on the sleeve, thence through a concrete interlock **59** to an abutment face **57** on the bar **19**.

Assume now that the sleeve structure **38** is used as a tension splice, such for example as if the bars **19** and **23** were substituted for the tension bars **31, 32** shown in the girder **13**. The line of tension force may be regarded as starting from an abutment face **58** on the bar **19**, thence through a concrete interlock **59** to an abutment surface **56** on the sleeve **38** as indicated by arrows **60***a* and thence through the sleeve to an abutment surface **52** thereof, and through an interlock **59** to an abutment face **54** on the bar **23**.

The flat portion **43** of the wedge member **39** has formed therein a series of apertures designated **61** which are similar to the apertures **51** and **55** and function as auxiliary passageways for delivering grout into the channels of both bar ends **19** and **23** through the slit opening **40** in the sleeve element.

Referring now to FIGS. 10 to 15, inclusive of the drawings: The splice structure of FIGS. 4 to 9 is utilized in FIGS. 10 to 15, with slight modification, to connect reinforcing bars of different diameter classifications.

FIG. 10 illustrates a building structure which includes a main column **62**, an upper extension column **63**, a horizontal beam or grider **64** and intermediate columns **65–66**, the latter of which are located at opposite sides of a corridor **67**. The spaces **68–69** at either side of the corridor may be substantially wider than the corridor. Consequently, the overlying areas of the grider **64** are reinforced with reinforcing bars **70** of larger diameters than the bars **71** overlying the corridor **67**. Also the bars **72** and **73** located in column **62** and its extension **63**, respectively, are of different diameters and are connected by the modified splice **27***c*, since it is usual practice to reduce the diameter and weight of the reinforcing bars as the height of a building is increased.

The truss bar section **74–75** located in the girder are of the same diameter and are therefore connected by splice **27***b* which corresponds in structure to the splices **27** and **27***a* as shown in FIGS. 1 to 9, inclusive of the drawings.

The splices **27***c* for connecting the bars **70–71** and **72–73** of different diameters shown in FIG. 10, include a split outer sleeve and a wedge of substantially the same construction as previously described in connection with FIGS. 4 to 9, inclusive. Consequently all corresponding parts of the splice members shown in FIGS. 11 to 15, inclusive are identified herein by the same reference numerals used in connection with the description of the splices shown in FIGS. 4 through 9, but include the letter *c*.

The modified splice structure **27***c*, for purpose of convenience, is illustrated and will be described in detail with respect to its position in the column extension **63**. However, such description also applies to the horizontal splices of the bars **70–71**.

The bar **63** may be the same in all respects as the bar **23** of FIGS. 5 and 6. A pair of semicylindrical reducer sleeve sections **76** are adapted to be applied to the lower

end of bar 73 and seat on the upper end face 78 of the bar 72 so that the diameter of bar 73 plus the combined thickness of the reducer sleeve sections 76—76 will correspond to the diameter of the diameter of the lower bar 72. The adjacent end faces of the bars 72–73 are positioned in angular relation to each other and thereby provide a slight clearance space 79, as shown in FIG. 8, to be filled with a body 80 of concrete grout as hereinafter described.

The upper and lower ends of each reducer sleeve section are provided with recesses 77, either of which will register with the inspection openings 46c and 47c formed at the mid point of the sleeve element 38c. Each reducer sleeve section is also formed with a series of apertures 81 which registers with the apertures 51c formed in the end portion of the sleeve element 38c which embraces the reducer sleeve and the lower end of the smaller bar 73. Both groups of apertures 51c and 55c formed in the split outer sleeve element 38c and the apertures 81 formed in the reducer sleeve sections 76 function as passageways for insuring free flow of concrete grout into the channels 35c between the deformation ribs 34c on the bars 72, 73.

The several parts of the splice structure 27c are assembled as follows: The split sleeve element 38c is first inserted over the upper end of the larger bar 72 and moved to a position below the upper end face 78 thereof. The bar 73 is then seated endwise upon the end face 78 of bar 72 as shown in FIG. 11. The semicylindrical reducer sleeve sections 76—76 are then fitted about the lower end of the bar 73. The outer sleeve element 38c is then moved upwardly to enclose the reducer sleeve sections 76 and the outer sleeve element 38c is turned to position its inspection openings 46c, 47c in register with the lower recesses 77 of the reducer sleeve sections. The wedge member 39c is then engaged over the wedge flanges 41c–42c and then driven downwardly to circumferentially contract the outer sleeve member 38c into constrictive gripping contact with the perimeter of bar 72 and to exert like constrictive gripping pressure, through the reducer sleeve sections 76, against the perimeter of the bar 73. The reducer sleeve sections have some circumferential flexibility; consequently, the contraction of the outer sleeve element 38c under the pressure exerted by the wedge 39c flexes the reducer sleeve sections sufficiently to compensate for tolerance variations in the diameter and/or perimeter contour of the bar 73.

During the pouring of the concrete to form the main concrete structure of FIG. 10, concrete grout flows from the main concrete body 10c into the sleeve 38c at the junction of the end faces 78–79 of the bars 72–73. If there is any clearance space between said end faces the concrete fills such space to provide a concrete bed or body 80 between the said end faces of the bars. The flow path for the concrete grout is defined by apertures 46c–47c formed in the outer sleeve 38c and aligned with recesses 77 adjacent thereto formed in the reducer sleeve sections 76. The grout is substantially confined within the space defined by the inner walls of the reducer sleeve sections 76 and therefore constitutes a non-compressible body for transmitting compression forces across the end faces of the bars 72–73. The concrete grout also flows through passageways defined by apertures 55c of the sleeve 38c into the channels 35c of the bar 72 to form key-like interlocks 59c between abutments 56c on the sleeve 38c and abutments 57c on the bar 72. Similar key-like interlocks 59c are formed by quantities of concrete grout which flow into the channels 35c of the bar 73 through apertures 51c formed in the sleeve 38c and registering with apertures 81 formed in the reducer sleeve sections 76.

When the sleeve structure 38c is used as a compression splice, the line of compressive force leads from the abutment face 53c on bar 73 through a concrete interlock 59c to an opposed abutment surface 52c (the perimeter of an aperture 51c) as indicated by the arrows 60c in FIG. 14 and thence through the sleeve 38c to the perimeter 56c of an aperture 55c serving as an abutment surface on the sleeve, thence through a concrete interlock 59c to an abutment face 57c on the bar 72.

When the sleeve 38c is used as a tension splice, the line of tension force may be regarded as starting from an abutment face 58c on the bar 72, thence through a concrete interlock 59c to an abutment surface 56c on the sleeve 38c as indicated by arrows 60ac and thence through the sleeve to an abutment surface 52c thereof, and through an interlock 59c in the direction indicated by arrows 60ac to an abutment face 54c on the bar 73.

I claim:

1. In combination with a concrete body, a metal reinforcement embedded therein including two reinforcement bars each having plural projecting deformation ribs spaced apart lengthwise thereof and defining multiple intervening channels having radially extending side walls constituting abutment faces, and splice means connecting the bars together in end-to-end relation, said splice means comprising a contractible sleeve embracing and gripping the adjacent ends of both bars and having a length sufficient to encompass a series of said ribs and intervening channels at the end of each bar, said sleeve having a plurality of side openings of dimensions generally comparable to said channels, said openings being distributed throughout the length and circumference of the sleeve and constituting passageways for admitting concrete grout into said channels during pouring of said concrete body to thereby afford a corresponding plurality of appendant concrete interlock segments extending from the main concrete body through the sleeve wall into the sleeve and interlocking the abutment faces on the bar deformation ribs with the internal surfaces of the sleeve apertures, said interlock segments serving to transmit both compression and tension forces from one bar to the other through the sleeve, said side openings being distributed longitudinally and circumferentially throughout said sleeve to assure complete peripheral interlocking of the sleeve with both bars.

2. A combination structure according to claim 1 in which the locations of the side openings in the contractible sleeve are such that the several center lines of tension-resisting force through the concrete interlock segments associated with one bar end of the splice and the center lines of tension-resisting force through the concrete interlock segments associated with the other bar end of the splice are inclined in opposite directions relative to the axis of the bars.

3. A combination structure according to claim 1 wherein said contractible sleeve is a circumferentially flexible metal sleeve having a longitudinal split with the opposite edges at the split turned laterally in opposite directions to form wedge-like flanges, and in which the split portion of said sleeve is closed by a wedge member having interlocked wedging engagement with said flanges and adapted upon movement of said wedge member in one direction relative to said flanges to constrict the split sleeve into firm gripping engagement with the perimeters of said deformation ribs on the end portions of both bars, said wedge member having a series of openings therein similar to the side openings in the sleeve distributed throughout the length of said wedge member, said openings in said wedge member defining additional passageways for admitting concrete grout into the split sleeve and into said channels between said deformation ribs.

4. A combination structure according to claim 3 wherein said split sleeve is circumferentially yieldable to accommodate bars of slightly different diameters and perimeter contours and wherein said openings in the wedge member and in the sleeve cooperate to increase the rate of yield under tension on the portion of the splice means which embraces the larger of the two reinforcement bars.

5. A combination structure according to claim 3 in which the reinforcing bars are of different diameter classification, said structure further including a two-segment

reducer sleeve substantially encompassing the reinforcement bar of smaller diameter within the split sleeve of the splice, said reducer sleeve having a plurality of side openings distributed throughout its length and constituting passageways for admitting concrete grout into the channels between the deformation ribs of the smaller bar and connecting with the corresponding passageways afforded by the side openings in the split sleeve.

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