March 26, 1957 L. COFF 2,786,349

PRESTRESSED CONCRETE BUILDING

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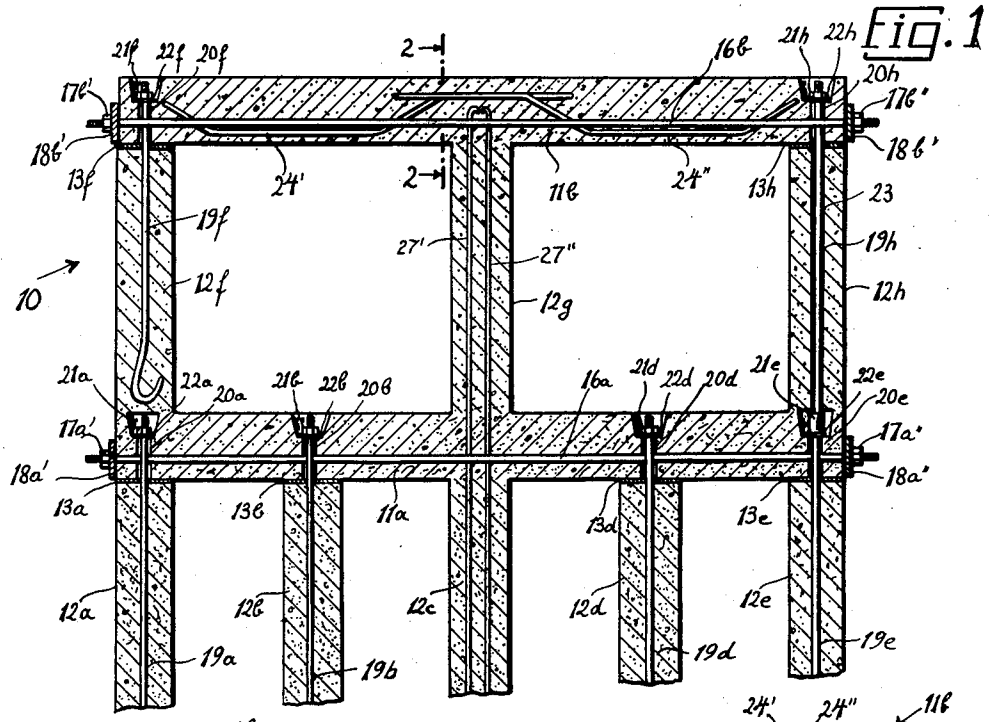


Fig. 1

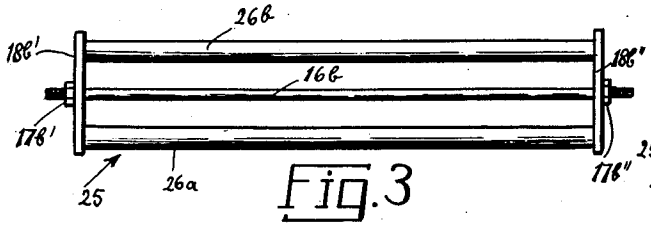


Fig. 3

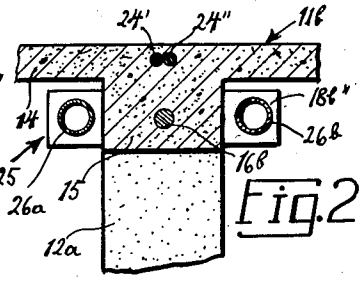


Fig. 2

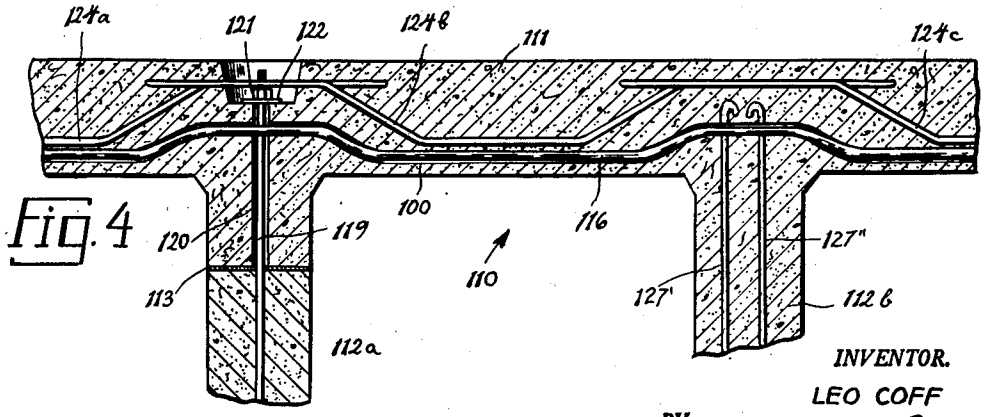


Fig. 4

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PRESTRESSED CONCRETE BUILDING

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3 Claims. (Cl. 72—15)

My present invention relates to a method of and means for erecting fully or partly prestressed concrete structures, particularly structures wherein a continuous span extends over a number of columns or other supports including two end supports and one or more intermediate supports.

In prestressed concrete structures tension is initially applied to an elastic member (e. g. a rod or a cable) which is subsequently transferred to the concrete in such manner as to place the latter in compression, this compression being superimposed upon any tensile stresses due to load so as either to cancel out these stresses or else to reduce them to a magnitude less than the tensile strength of the concrete, whereby cracking of the layer or slab representing the concrete section will be prevented. For partial prestress the tensionable member or members are supplemented by additional reinforcements, usually of larger cross section and of lower-quality steel, which are not tensioned but to which compression is initially imparted from the tensioned members through the intermediary of the concrete. The magnitude of the prestress and, hence, of the initial compression imparted to the ordinary (unprestressed) reinforcements will be such that any resulting cracks will be non-objectionable or that the development of such cracks will again be completely prevented.

For an evaluation of the possibilities realizable with variations in the relative dimensioning of the normal reinforcements and the tension members, and for a detailed and exhaustive analysis of the theory underlying partial prestress, reference is made to U. S. Patent No. 2,255,-022, granted September 2, 1941, to F. Emperger, and to Emperger's publication entitled "Stahlbeton mit vorgespannten Zulagen aus hochwertigem Stahl," June 1939, Wilhelm Ernst & Sohn, Berlin (Germany).

Heretofore, however, the use of prestressed or partly prestressed concrete has found little favor for continuous structures, having in general been limited to a few bridges. As far as I am aware, the longest continuous span of prestressed concrete to-date constructed is a bridge near Stockholm, Sweden, spanning the Klockestrand Sound, which was erected between 1938 and 1943 and is a partly prestressed bridge. (For a description of this structure see Reports of Third Congress of the International Association for Bridge and Structural Engineering, Liège (Belgium), Sept. 13–18, 1948, p. 381.) The reasons for this reluctance on the part of builders to employ full or partial prestress in such structures may be summarized as follows:

Whereas in the case of a simply supported beam the correct disposition of each tension member is along a sagging line while satisfactory results may already be obtained with a straight member extending horizontally below the neutral axis, conditions are vastly different for a continuous span where the theoretical locus for the tension member is a sinuous curve approaching (but not necessarily intersecting) the neutral plane above the supports. If post-tensioning is used, i. e. if tensioning takes

place after the concrete has hardened, the problem is not too difficult since the tension member may be disposed within the concrete in any desired manner; means must, of course, be provided to prevent the bonding of the concrete to the cable serving as the tension member, such means being, for example, in the form of a steel or rubber sheath surrounding the latter. If the supports are numerous, however, i. e. if the curve is rich in sinuosities, then the friction between the cable and the concrete may become excessive and a substantial part of the tension sought to be imparted to the cable will be communicated to the concrete, which of course is undesirable and defeats the purpose of prestressing. Also, reasons of economy make it desirable that the sheathing be withdrawn from the slab after the hardening of the concrete has been completed, in which case the situation referred to will be aggravated since the coefficient of friction between steel and concrete is relatively high. Where, on the other hand, the tension members are to be stressed against suitable reaction members before the concrete has hardened (a procedure known as pretensioning), no practical solution has yet been found to place and to maintain the cable in its desired curvilinear shape prior to the hardening of the concrete; accordingly, pretensioning has generally been limited to structures for which straight tension members are suitable.

Another objection to the prestressing of continuous spans resides in the fact that any prestressing of the horizontal beam or slab will tend to shorten its length, thereby either causing the slab to move relative to its supports or, if this is impossible (as where the slab is conventionally supported on columns), to effect the displacement of these supports (e. g. bending of the columns). For these reasons it will be necessary to overcome a not inconsiderable resistance, e. g. the flectional resistance of one or more columns, before the desired prestress can be imparted to the structure. It may be noted that this problem is of lesser importance in the case of bridges wherein, as proposed by Finsterwalder (U. S. Patent No. 2,155,121 of April 18, 1939), all supports except one may be conveniently mounted on rollers or similar low-friction bearings; such an arrangement, however, is out of the question in building construction.

A primary object of my present invention is to provide means enabling a continuous structure, as hereinabove defined, to be prestressed (in full or in part) without giving rise to the difficulties referred to.

Another important object of this invention is to provide means enabling a continuous span to be prestressed, in full or in part, with the aid of one or more tensionable members extending along a straight line within the span.

A further object, allied with the immediately preceding one, is to provide a unit adapted to be used in the pretensioning of either simple or continuous spans, said unit comprising one or more members tensioned, preferably at the factory, against suitable reaction means.

Still another object of the invention is to provide a method of and means for giving greater leeway to the positioning of a tension member in a continuous structure by producing a positive moment independent of said tension member above the intermediate support or supports of the structure.

The invention will be described in detail with reference to the accompanying drawing in which:

Fig. 1 shows, in longitudinal section, part of a multistory building according to the invention;

Fig. 2 is a cross section taken on the line 2—2 of Fig. 1;

Fig. 3 is a top plan view of a prestressing unit according to the invention used in the erection of the structure of Figs. 1 and 2; and

Fig. 4 is a view, on a somewhat larger scale, similar to Fig. 1, showing a modified structure according to the invention.

Referring first to Figs. 1 and 2, there is shown a structure **10** comprising a lower floor **11***a* and an upper floor **11***b*, floor **11***a* being supported on five columns **12***a*, **12***b*, **12***c*, **12***d* and **12***e*, floor **11***b* being supported on three columns **12***f*, **12***g* and **12***h*. Columns **12***f*, **12***g* and **12***h* are respectively aligned with columns **12***a*, **12***c* and **12***e*.

In order to allow for the relative movement between the floors and the supporting columns when the structure is horizontally prestressed, by means hereinafter described, only the central columns **12***c*, **12***g* are monolithically united with the floors **11***a*, **11***b* respectively resting thereon, the remaining columns being separated by suitable anti-friction layers or joints **13***a*, **13***b*, **13***d*, **13***e*, **13***f* and **13***h* from the beams they support. These layers may consist of metal plates, asphalted paper sheets or other materials well known per se for such purposes.

As shown in Fig. 2 for the upper floor **11***b*, each floor is in the form of a T-beam consisting of a flange **14** and a web **15**. A tension member in the form of a straight rod **16***b* extends horizontally within the web **15** of floor **11***b*, and a similar rod **16***a* passes in like manner through the floor **11***a*. The rods are held under tension by nuts **17***a'*, **17***a''* and **17***b'*, **17***b''* engaging respective ends thereof and bearing upon anchor plates **18***a'*, **18***a''* and **18***b'*, **18***b''*, respectively, the latter in turn abutting the ends of the webs of the corresponding T-beams.

Since the tension members **16***a*, **16***b* extend below the neutral planes of the associated beams, they will impart negative moments to the latter, thereby tending to lift the beams off their supports. To counteract this tendency in the case of the supporting columns which are not bonded to the overlying beams, i. e. in the case of columns **12***a*, **12***b*, **12***d*, **12***e*, **12***f* and **12***h*, I provide each of these columns with a vertically disposed tension element **19***a*, **19***b*, **19***d*, **19***e*, **19***f* and **19***h*, respectively, these vertical elements extending through the corresponding anti-friction layers **12***a* . . . **12***h* and through channels **20***a*, **20***b*, **20***d*, **20***e*, **20***f* and **20***h*, provided in the floors above these columns, which are sufficiently wide to allow for the necessary relative movement between these floors and their supporting columns. Two normal reinforcing elements **27**,' **27**'' extend vertically within both of the two bonded center columns **12***c* and **12***g*, the floor **11***a* and part of the floor **11***b*.

After the prestressing of, say, the lower floor has been completed, i. e. after the tensioned member **16***a* has been released against the beam **11***a* so as to place the same under compression (and after waiting, if necessary, a certain period to let shrinkage and plastic flow take its course), the vertical elements **19***a* . . . **19***e* are in their turn tensioned and released against the same beam so as to urge its web portion into firm contact with the supporting columns, thereby counteracting the aforesaid negative moment developed above these columns. A like procedure is followed in the case of the upper floor **11***b*. The upper ends of these vertical elements project, for this purpose, into recesses formed in the overlying beams as a continuation of the channels **20***a* . . . **20***h* and are engaged by suitable abutment means **21***a*, **21***b*, **21***d*, **21***e*, **21***f* and **21***h* which bear upon plates **22***a*, **22***b*, **22***d*, **22***e*, **22***f* and **22***h* resting on the bottom of these recesses.

For the sake of illustration I have shown the extreme left-hand tension elements **19***a*, **19***f* as separate members each anchored in its associated column **12***a*, **12***f*, whereas the corresponding elements **19***e*, **19***h* on the right are united into a single member extending through both columns **12***e*, **12***h* and through both floors **11***a*, **11***b*. Whereas, therefore, the abutment means associated with the elements **19***a*, **19***b*, **19***d*, **19***f* and **19***h* may be simple nuts as shown, similar to the nuts **17***a'*, etc., I have shown the abutment means **21***e* as an offset formed around an intermediate portion of the member **19***e*, **19***h*. Such an offset may be affixed to the tensioning member in various ways; where the latter is a plain rod, as shown, welding may be satisfactory, whereas in the case of a cable it will be possible to use any conventional type of clamp. Reference is made to my co-pending applications Ser. No. 91,074, filed May 3, 1949, and Ser. No. 203,659, filed December 30, 1950, wherein I have disclosed various methods of forming an offset on a cable and on a rod, respectively.

Since the tension element **19***h* is effectively anchored in the lower column **19***e*, it will not be necessary to have this element bonded to its column **12***h*, wherefore the latter may be provided with bond-breaking means such as a channel **23** surrounding the element **19***h*. It will also be apparent that in some instances the tensioning of the element **19***e* may be deferred until after the upper floor **11***b* has been completed, in which case the offset **21***e* may be omitted, together with the bearing plate **22***e*, and tension imparted to the members **19***e*, **19***h* in its entirety at the upper end thereof, this tension being maintained by the nut **21***h* resting upon bearing plate **22***h*.

If partial prestress only is desired, the horizontal tension members **16***a*, **16***b* may be supplemented by additional, unprestressed reinforcements as shown for the upper floor **11***b* at **24'**, **24''**. It may be mentioned that the number of prestressing members and unprestressed reinforcements, as well as their relative section, is subject to a wide range of variations readily determinable, according to need, from the teachings of Emperger in the patent and in the publication referred to.

Fig. 2 also shows how the rod **16***b* forms part of a unit, generally designated **25**, adapted to be used for pretensioning purposes by providing reaction means against which the rod can be stressed before the concrete has hardened. This unit, shown by itself in Fig. 3, comprises a pair of pipes **26***a*, **26***b* extending parallel to the rod **16***b* on opposite sides thereof, the anchor plates **18***b'*, **18***b''* bearing upon the ends of these pipes under pressure from the member **16***b* tensioned by the nuts **17***b'*, **17***b''*. Since this pressure is all that holds the pipes **26***a*, **26***b* between the plates **18***b'*, **18***b''*, and since the pipes are not imbedded in the concrete floor **11***b* but extend alongside the web **15** thereof, it follows that these pipes may be readily removed from the structure after the concrete has hardened sufficiently to have the stress of the rod **16***b* transferred to it. Tensioning of the rod **16***b* against the pipes **26***a*, **26***b* may be done at the factory, thus dispensing with the need for using hydraulic jacks or the like on the building site.

Fig. 4 shows a structure **110** which is similar to that of Fig. 1 but wherein the floor **111**, supported by columns **112***a*, **112***b*, has been prestressed by the post-tensioning of a tension member represented by a cable **116**. The tensioned cable **116** passes through a channel **100** which extends along a sinuous curve within the beam **111** without, however, intersecting the neutral plane thereof, this arrangement giving rise to negative moments even above the supports **112***a*, **112***b*. Unprestressed reinforcements **124***a*, **124***b*, **124***c* supplement the tension member **116** within the beam **111**.

While one of the columns, here column **112***b*, is again shown monolithically united with the floor **111** supported thereby, a major portion of the other column **112***a* is separated therefrom by an anti-friction joint **113**. The joint is here shown spaced from the underside of the beam **111** and may, in fact, be provided anywhere along the column, even at the very bottom thereof. A channel **120**, disposed vertically within the beam **111** and extending into the upper portion of column **112***a* above the joint **113**, surrounds a vertical tension element **119** which is anchored in the lower part of the column. The upper surface of the concrete floor **111** is recessed to receive the top of element **119** which is engaged by a nut **121** resting upon a bearing plate **122**. Normal (unprestressed) reinforcements **127'**, **127''** extend vertically

within the column **112***b* and into the floor **111**. The arrangement is thus similar to that shown in Fig. 1 and functions in analogous manner.

The invention is not limited to the specific embodiments shown and described but may be realized in modified form, or adapted to other uses, without thereby exceeding the scope of the appended claims.

I claim:

1. In a concrete structure, in combination, a horizontal slab and means supporting said slab at least at three substantially aligned points, said supporting means including a first vertical column rigid with said slab and a second vertical column engaging said slab at an intermediate one of said points, an elongated tie member extending within said second column and projecting therefrom, said slab being provided with a vertical channel receiving the projecting end of said tie member with sufficient clearance to enable limited horizontal movement between said slab and said second column, an elongated prestressing member extending generally horizontally inside and substantially entirely below the neutral axis of said slab and under sufficient tension to impart a moment thereto tending to lift said slab off at least said second column, joint means between said slab and said second column facilitating said relative movement therebetween, and tensioning means engaging said projecting end of said tie member and exerting a downward pressure upon said slab, thereby counteracting said lifting moment above said second column.

2. The combination according to claim 1, wherein said joint means comprises an anti-friction layer extending transversely of said column.

3. The combination according to claim 1, further including unprestressed metal reinforcing means extending inside said slab in the general direction of said prestressing member, said reinforcing means being bonded to said slab and having compression imparted thereto from said prestressing member.

References Cited in the file of this patent

UNITED STATES PATENTS

903,909	Steiner	Nov. 17, 1908
1,516,074	Borg	Nov. 18, 1924
1,693,941	Schuster	Dec. 4, 1928
1,794,425	Sorenson	Mar. 3, 1931
1,867,185	Sorenson	July 12, 1932
2,155,121	Finsterwalder	Apr. 18, 1939
2,241,169	Yokes	May 6, 1941
2,413,990	Muntz	Jan. 7, 1947
2,590,685	Coff	Mar. 25, 1952

FOREIGN PATENTS

386,176	Great Britain	Jan. 12, 1933
639,399	Great Britain	June 28, 1950