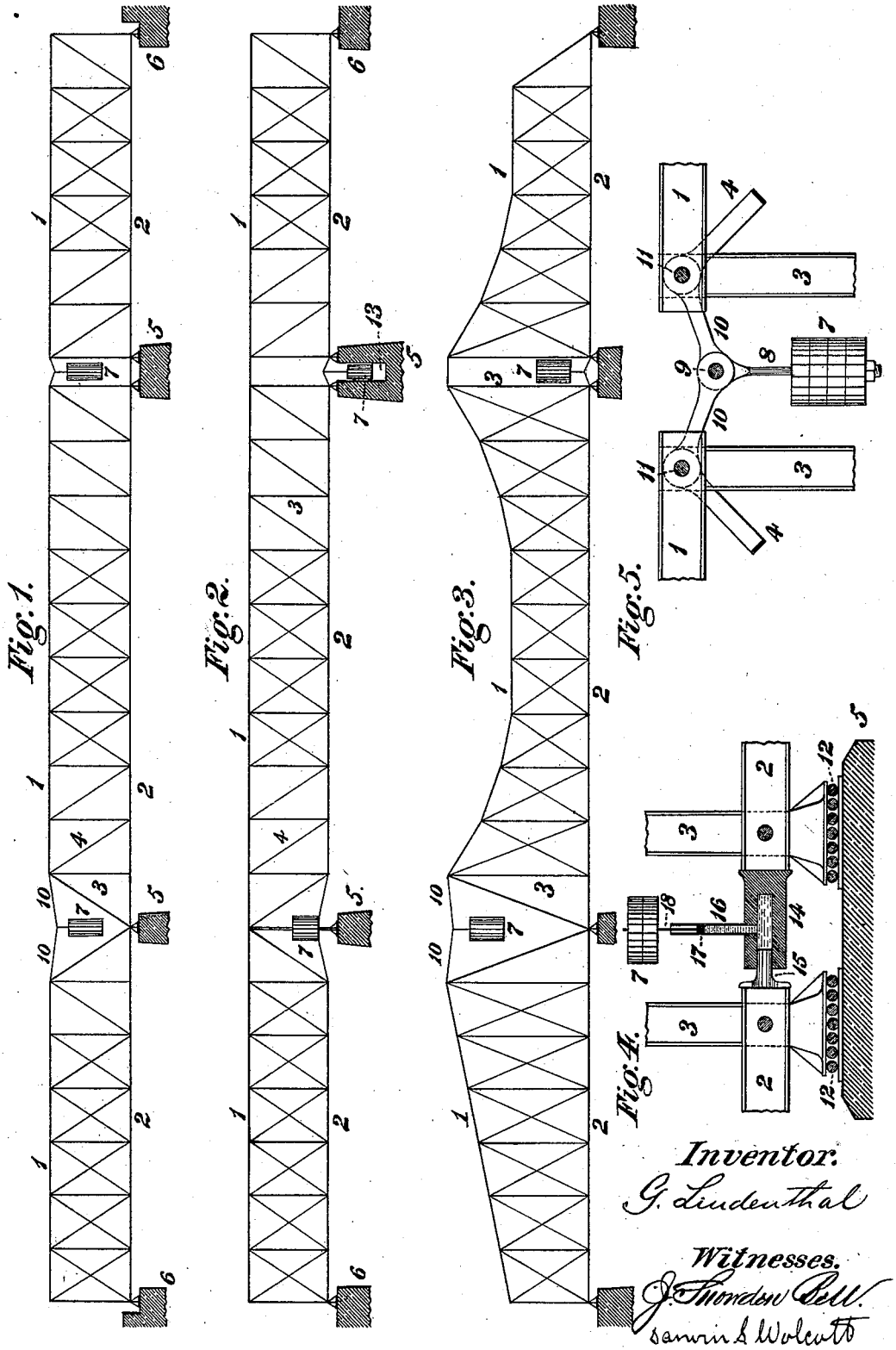
(No Model.)

G. LINDENTHAL.

CONTINUOUS GIRDER OR TRUSS.

No. 306,694. Patented Oct. 14, 1884.



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CONTINUOUS GIRDER OR TRUSS.

SPECIFICATION forming part of Letters Patent No. 306,694, dated October 14, 1884.

Application filed July 18, 1884. (No model.)

To all whom it may concern:

Be it known that I, GUSTAV LINDENTHAL, a citizen of the United States, residing at Pittsburg, in the county of Allegheny and State of Pennsylvania, have invented or discovered certain new and useful Improvements in Continuous Girders or Trusses, of which improvements the following is a specification.

In the accompanying drawings, which make part of this specification, Figures 1, 2, and 3 are diagrammatic views of continuous girders or trusses embodying my invention, and Figs. 4 and 5 views on an enlarged scale of constructions adapted to impart fixed strains to the chords thereof.

The object of my invention is to so construct what are known as "continuous girders or trusses"—that is to say, those which extend over two or more spans of a bridge structure—that the application of load to each or all of the spans of the girder shall not affect the adjacent spans beyond a certain determined limit, in contradistinction to the usual construction, in which the live load on every different point in any span affects the adjacent spans in a different and, to a greater or less degree, uncertain manner.

A further object of my invention is to render continuous girders or trusses independent of the settling of their supports on piers or abutments, as distinguished from continuous girders of the ordinary construction, in which the settling of any one of the supports effects a greater or less change in the strains of the different bridge members.

To these ends my invention, generally stated, consists in the combination, with a continuous girder or truss having one or both of its chords divided into separate spans or sections, of means for imparting fixed strains to the chords above their piers, and thereby producing in the truss a pier or chord moment of known and fixed value.

The improvements claimed are hereinafter fully set forth.

Solid beams and framed beams, known as "trusses," are subject to the same laws of deflection under loads. Two kinds of deflection are induced in a continuous beam or truss of more than one span, one of which is downward between the supports and the other upward directly above intermediate supports or piers. It will be evident that deflection above the pier acts to produce tension in the upper part of the beam (or top chord of the truss) and compression in the lower part of the beam, (or lower chord of the truss,) and that tension and compression must be equal. It will further be evident that the value of tension and corresponding compression in the chords, or, in other words, the chord-moment above the pier, otherwise known as the "pier-moment" of the truss, will change for different locations of load. The determination of the value of the pier-moments and of the strains in the various bridge members is uncertain, for the reason that it is difficult to fulfill in practice the assumptions upon which the calculation must proceed—to wit, a uniform elasticity of material and freedom from unequal settlement of supports. In a continuous truss so devised, as in my invention, hereinafter described, that the strains which are induced are not affected by want of uniformity in the material or by unequal settlement of supports, the strains can be determined with great precision, and economy of material in the construction of the truss is attained thereby.

It is essential in the application of my invention that a constant and predetermined tension and a corresponding compression shall be imparted to the chords above the piers, and such result may be attained by different mechanisms acting to this end, instances of which are illustrated and described herein. Tension and compression being necessarily equal, it follows that if by the construction shown in Fig. 5 a certain known tension is induced in the top chords, a corresponding compression of equal value will be induced in the bottom chords, and similarly, if compression be induced in the bottom chords, as by the construction shown in Fig. 4, a corresponding tension of equal value will be induced in the upper chords. In each case a pier-moment of a certain constant and predetermined value is introduced into the truss and substituted for the fluctuating and uncertain pier-moment of rigid continuous trusses of the ordinary construction. The pier-moment can be chosen to support a portion of the weight of the truss, which if cut off at a certain distance from the pier would be supported in the manner of a bracket or cantilever. In such case any extraneous

load will not change the strains near the pier, but simply in bridge members between the piers, and all these strains can be accurately determined on the principle of the lever, as in ordinary single-truss bridges.

The calculation of strains in a continuous girder constructed in accordance with my invention is made on the principle of the lever, in the following manner: The strains induced in the girders by the known and fixed pier-moments are first computed, and thereafter the strains for each span, as though the same were single and rested at its ends without pier-moments. The algebraic sum of the strains of both calculations for each bridge member gives the resulting strain for the continuous girder of my construction. As the strains near the piers remain constant, and change slightly only in certain members, the members may be proportioned for greater unit-strains, which is an additional feature of structural economy.

Referring to the drawings, the application of my invention is illustrated, under different modifications of detail, in continuous-girder bridges composed of girders or trusses extending over a series of spans, and having upper chords, 1, lower chords, 2, and interposed posts or struts 3, and diagonal ties 4, said girders being supported upon piers 5 and abutments 6. In the girder shown in Fig. 1 the lower chord, 2, is made continuous for its entire length from one abutment to the other, and the upper chord, 1, is divided into separate spans or sections, each extending over one span of the structure. In the girder shown in Fig. 2 the upper chord is continuous and the lower chord divided into separate sections, as above specified, and in Fig. 3 the upper and lower chords are alternately divided.

For the purpose of producing in the truss a pier or chord moment of a certain known and unchangeable value, I locate intermediately between the adjacent ends of the several sections of the divided chord of the truss devices whereby a permanent tension and a permanent compression, each of a certain previously-fixed value, in accordance with the load designed to be sustained by the structure, are imparted to the upper and to the lower chords, respectively. Such application of permanent strain may be made either by means of weights, as in Figs. 1 to 3, and as illustrated in detail on a larger scale in Fig. 5, or by hydraulic pressure, as shown in Fig. 4. In the former case a weight or series of weights, 7, is connected to a supporting rod or chain, 8, which is coupled by a pin, 9, to one or more pairs of links, 10, the opposite ends of which are in turn coupled by pins 11 to the adjacent ends of two spans of the divided chord, the transmission of the pressure of the weight to the upper and lower chords being such as to exert tension upon the upper and compression upon the lower, as indicated in the several figures. The end posts, 3, of the spans are supported through the intermediation of rollers 12 on the piers 6, so as to admit of the required degree of movement of the sections of the divided chord under the action of the applied strain, and to prevent interference of the weights with the roadway-space of the girder, as well as to conceal them from view, they may be suspended in recesses 13 in the piers 5, as shown in the right-hand pier of Fig. 2. The suspending rod or chain may, further, be dispensed with, and the weight guided by a post extending from a continuous upper chord to a pier between the ends of two spans of a divided lower chord, as in the left-hand pier of Fig. 2.

It will further be obvious that other modifications in the connection of the weights with the chord-sections may be made by those skilled in the art of bridge-construction without departing from the principle of my invention.

Fig. 4 illustrates a construction in which the application of the required permanent strains is effected by means of hydraulic pressure. A cylinder, 14, secured to one end of a span of a divided lower chord, is fitted with a piston or plunger, 15, which bears against the adjacent end of the adjoining lower-chord span. A cylinder, 16, communicating with the cylinder 14 and of smaller diameter than the same, is fitted with a piston, 17, to which pressure may be applied by a weight, 7, a screw, or other suitable means. The space within the cylinders 14 and 16 being filled with water or other incompressible liquid, pressure applied to the piston 17 is exerted in an increased degree proportionately to the difference of areas of the cylinders upon the plunger 15 and the opposite end of the cylinder 14, thereby imparting compressive strain to the lower-chord sections, and, through the connections of the chords, correspondingly imparting tensional strain to the upper chord.

Either of the devices above described, or suitable modifications thereof, may be adopted at the option of the constructer; and it will be obvious that the application of strain may be made to either chord of the girder, or to each alternately, with the production in each case of the same desired result of producing a known and fixed pier or chord moment in the structure.

My improvements are applicable in connection with chords of any desired form suitable for continuity over the piers—as, for example, the chords may be straight and parallel, converging or diverging, or the upper chord may be curved in the manner of a cable, while the lower cord is straight. The upper chord may be straight and the lower chord curved as an arch, or both chords may be curved toward the horizontal middle line of the truss, so that its greatest depth shall be above the piers and its least intermediate between the same.

I am aware that a construction has been heretofore proposed and made the subject of Letters Patent, in which separate and adjoining girders are connected above piers by a fu-

nicular arrangement of links and ties, adjustable by means of screws, keys, or wedges, or by a system of similarly-adjustable toggle-joints, in order to enable each span to separately expand and contract under temperature changes without change in the pier-moments. Such construction, which I hereby disclaim, differs from my invention in the essential particular that it does not contemplate or provide means for the introduction of a constant and predetermined pier-moment; but, on the contrary, its pier-moments vary under moving loads in the same manner and degree as in the case of rigidly-connected trusses, and, further, for uneven settlement of the supports the lengths of the connecting ties, links, or toggle-joint connections require to be adjusted. The calculation of strains in a structure of such character does not differ from that in which the girders are rigid over their supports on the piers, being based on the theory of deflection and on a uniform modulus of elasticity of the material in the trusses. Such uniform elasticity is difficult, if not impossible, to obtain in practice, and hence the theoretical economy of continuous girders is not safely attainable. Under my invention the strains are calculable with great precision on the principle of the lever, as in single trusses. The pier-moments in the truss are known and constant under all loads, whatever their position, and in case of unequal settlement of supports the pier-moments adjust themselves automatically in accordance therewith. No provision is made for the separate expansion or contraction of the several girder-spans, although, if desired, the same could be provided for by the employment of a separate pressure device for each chord, so as to separately induce tension in the upper and compression in the lower chord. The application of the pressure device to one chord only, either the upper or lower, as may be most convenient, is, however, deemed preferable by me.

I claim herein as my invention—

1. The combination, in a truss or girder, of an upper and a lower chord, one of said chords extending continuously over two or more spans and the other being divided into sections at the ends of spans, and a pressure device interposed between the adjacent ends of two spans of a divided chord, and operating, as described, to impart a determined and permanent strain of tension to the upper chord of the girder and a corresponding strain of compression to the lower chord thereof, substantially as set forth.

2. The combination, in a truss or girder, of a continuous chord, a chord divided into separate sections above one or more of its supports, and a weight coupled to the adjacent ends of two sections of the divided chord, substantially as set forth.

3. The combination, in a truss or girder, of a continuous chord, a chord divided into separate sections above one or more of its supports, a pier having a vertical recess or opening in its top and supporting the adjacent ends of two sections of the divided chord, and a weight suspended within the recess of the pier and coupled to the sections of the divided chord which are supported thereon, substantially as set forth.

In testimony whereof I have hereunto set my hand.

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