No. 680,906. Patented Aug. 20, 1901.

F. J. ARNODIN.

COUNTERBALANCED AND JOINTED SUSPENSION BRIDGE.

(Application filed June 18, 1901.)

(No Model.)

Fig. 1

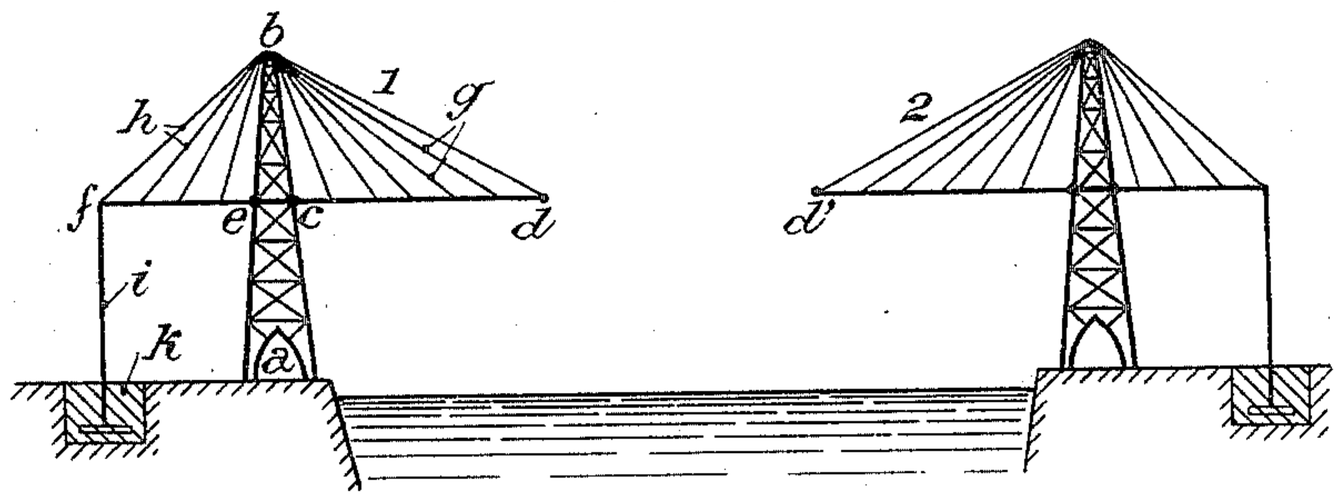


Fig. 2

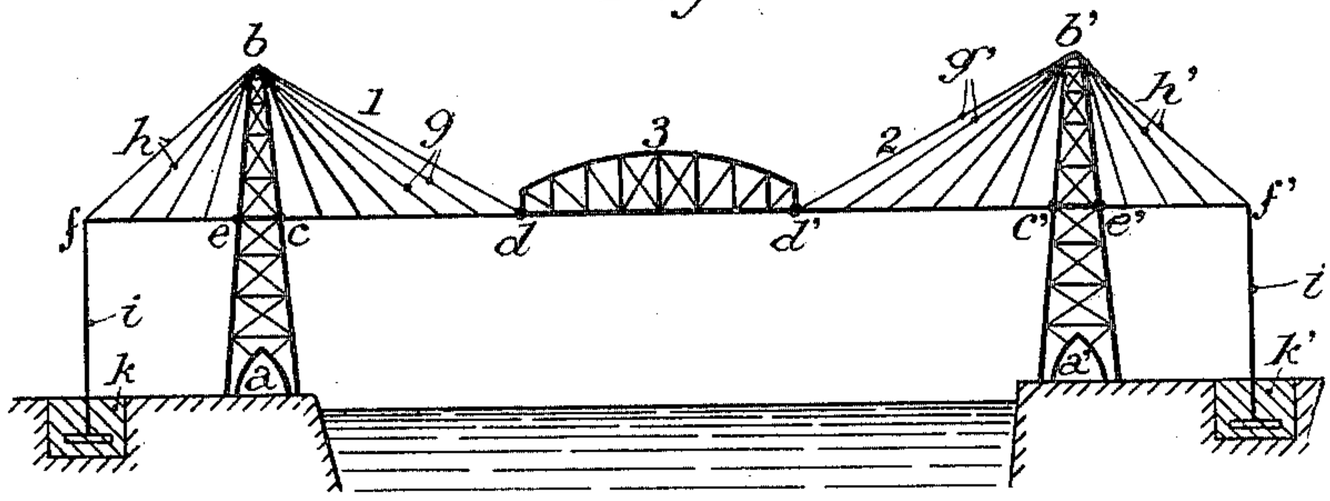
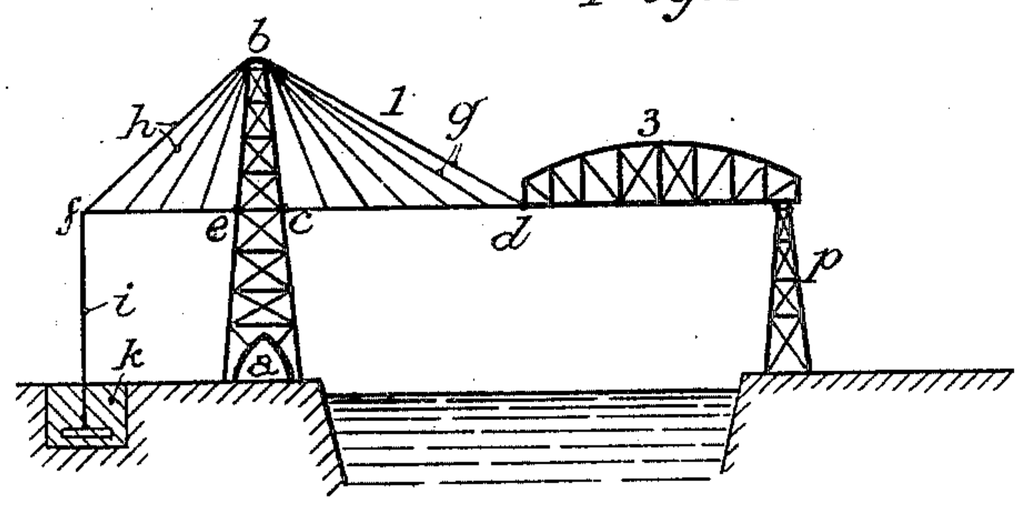


Fig. 3



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FERDINAND JOSEPH ARNODIN, OF CHÂTEAUNEUF, FRANCE.

COUNTERBALANCED AND JOINTED SUSPENSION-BRIDGE.

SPECIFICATION forming part of Letters Patent No. 680,906, dated August 20, 1901.

Application filed June 18, 1901. Serial No. 64,972. (No model.)

To all whom it may concern:

Be it known that I, FERDINAND JOSEPH ARNODIN, engineer, a citizen of the Republic of France, and a resident of Châteauneuf-sur-Loire, Loiret, France, have invented new and useful Improvements in Counterbalanced and Jointed Suspension-Bridges, of which the following is a specification.

Bridges suspended by parabolic or oblique cables and which offer numerous advantages for spanning large spaces or outlets have, however, the disadvantage that there is an oblique strain on the top of the supporting-piers, which tends to overthrow the latter toward the center of the space bridged over. In order to obviate this tendency, it is in most cases necessary to employ cables to secure the piers, which derive the necessary reaction from an anchorage of masonry situated at a relatively great distance behind the pier, or in exceptional cases the pier itself is made of masonry so massive and heavy as to resist the overturning tendency which the tension of the cables causes. In the case of very elevated bridges—such as those used for transporting merchandise, passengers, and the like—which are placed above navigable water-ways, it is not practicable to make the piers of masonry nor to make them sufficiently massive. On the other hand, there are certain cases where in consequence of its being necessary to relinquish certain house property or in consequence of any other local circumstance that insurmountable difficulties are experienced in order to find a site or sites for the anchoring masonry. Finally it sometimes happens that the ground available is so insecure or shifting that it would be dangerous to build thereon masonry, which would be subjected to oblique strains, and apprehensions on this score have sometimes had the effect of preventing the erection of suspension-bridges of such a nature. Having been frequently confronted by these diverse situations, it has occurred to me to devise a method of and means for obviating these difficulties, and this present application for patent relates to an invention according to which there is absolutely no oblique strain put on the piers nor on the anchoring masonry and whereby it is possible to place the anchoring masonry at a relatively short distance from the piers.

Figure 1 of the accompanying sheet of diagrammatic drawings represents in elevation parts of a bridge made according to this method. Fig. 2 shows in elevation the finished bridge, and Fig. 3 is a similar view of a modification.

Bridges constructed according to this invention consist, essentially, of three parts—namely, the two end or lateral parts (marked 1 and 2 on Figs. 1 and 2 of the accompanying sheet of drawings) and the middle or intermediate part (marked 3) connecting the two former parts, as shown in Fig. 2. The two end parts 1 and 2 are or may be made in the same manner. For example, that on the left consists of, first, a high pier *a b*, made of masonry, of wood, or of metal, which is only subject to vertical compression, and, secondly, a large girder or beam *c d*, which is connected by a joint *c* at one end to the pier at some distance down and supported by an expansion or jointing device at the top *b* of the same by oblique cables, such as *g*, the other ends of which are connected to the girder at varying distances from the pier. The joint at *c* between the girder and the pier permits the said girder to follow the movements due to expansion and contraction and the tension or slackness of the cables without being restrained by its solidarity with the pier and without exercising strain on the latter at the places where the union of the parts is effected.

In order to counteract the strain on the top *b* of the piers by the cables *g*, another girder *e f* is mounted behind or on the other side of the pier at the same level as the first-described girder *c d*. This second girder is made of such a length as is in accordance with the site and general conditions thereof, and it is supported at varying distances from its joint *e* on the pier *a b* by a number of cables *h*, attached to the top of the said pier, it being understood that the joint on the pier is similar to and for the same purpose as the joint between the pier and the first-described girder.

If, for example, the first-described girder *d c* is made twice the length of that secondly described and designated by the letters *e f*

and if the weight of the latter is double that of the former, the said parts will be in equilibrium, and the resulting strains will be at *b*, or, in other words, the pressure on the pier will be vertical. It will be easily understood that the proportions between the first-described girder *d c* and the second girder *e f* may vary without destroying the principle of the vertical pressure, providing that the weights at the outer ends of the girders are varied in such manner that they conform to each other.

In order not to put too much weight on the outer end of the second girder *f*, cables *i* to a sufficient number and of the necessary strength are connected to the outer end of the girder and descend vertically from that point to the ground wherein or whereon they are anchored in an anchorage of masonry, and the weight of the latter is calculated to be at least sufficient to give to the said outer end *f* that weight which is wanting in order to counteract any weight which might be upon the outer end *d* of the first girder. Under these conditions the horizontal stresses which are transmitted by the girders at their points of junction with the piers at *e* and *c*, respectively, are of the same magnitude and reciprocally annul each other.

The principle on which the invention is based naturally remains the same if instead of cables one employs rods of metal, wood, or other suitable material; but cables have been mentioned at first, because they are more capable of resisting tension with safety.

The first-described girder, which has been referred to by the letters *c d*, is intended to carry the roadway or the rails for a suspended vehicle for transporting passengers, merchandise, and the like, and it is evident that such a construction allows of spanning a part of the width of a river or a valley or any other obstacle.

If an exactly-similar construction consisting of a pier, two girders, cables, and anchorage be built on the opposite side of the river or other obstacle, another part of the distance across is similarly spanned; but it is not essential that the respective lengths of the corresponding girders should be the same on both sides of the river or the like.

From what has been hereinbefore stated it is apparent that two points of support are produced by the outer ends *d* and *d'* of the girders between the two piers, and it is easy to construct or suspend a bay or connecting part between the said girders of such a strength or weight as is consistent with the resistance to the strain on the cables, the resistance to compression of the girders and of the piers, and the weight or resistance of the counterweights or anchorages.

It is easy to dispose a more or less rigid-framed bay or connecting part, made of iron or wood, which is, in fact, a kind of small bridge 3, Fig. 2, spanning the central gap and of which the points of support *d* and *d'* are jointed to the girders. The object of providing this central bay is to insure that the weights which pass by a kind of jointed connection from the end *d* of one girder to the opposing end *d'* of the other girder shall only promote stresses which are easily analyzed and are not productive of harm to the structure. As a matter of fact it is clear that when a moving load passes over one of the girders *c d* the outer end of the latter will be lowered; but owing to the intermediate jointed bay or connecting part and to the joint or hinges of its points of support this sinking down can take place without any pernicious effect on the several component parts. That end *d* of the connecting part will follow the sinking down, which will be at its maximum when the moving weight is at the point of junction *d* between the connecting part and the aforesaid girder. As the moving load progresses along the connecting part and reaches the middle thereof the weight of the moving load and of the connecting part will be equally borne between the opposing ends of the two girders and both ends will be at the same level. Continuing on its way, the load will pass on to the other girder, of which the end *d'* will be depressed, while the end of the first girder will rise, these displacements depending merely upon the tension of the cables, the movements of which are not opposed by any contrivance of the structure. As the strains can be easily analyzed and are easily computable, it follows that this construction gives all the requisite safety. It may further be suitably mentioned that the depressions of the ends of the girders at *d* and *d'* are not of much importance, as they move solely according to the strain on the cables. In this manner the problem is solved of how to construct a bridge which shall not exercise any oblique pressure on the ground.

In certain cases, and particularly where it is possible owing to local circumstances to anchor only on one of the banks, only one of the end bridge parts (marked 1 and 2 on the drawings) need be employed, and on the other bank it suffices to have a simple support, made of wood, masonry, or iron, capable of sustaining one end of a connecting part, as previously described, of which connecting part the other end is jointed to the outer end *d* of the girder mounted on the pier on the first-mentioned bank. Fig. 3 shows such a construction, which comprises, first, on one bank the part 1, (or 2,) as described; secondly, on the opposite bank a pier *p* of height suitable to equal the level of the girders *e f c d* and provided at the top with an expansion device, and, thirdly, the connecting bay or part 3, connected at one end by the joint or hinge *d* to the girder *c d*, the other end being mounted on the expansion device arranged at the top of the pier *p*.

I claim—

1. In a bridge the combination of a pier *a b* erected on one bank, girders or beams *c d*

jointed at one of their ends *c* to one side of the pier at some distance from the top thereof, girders or beams *e f* mounted on the pier in the same manner as those first mentioned at the same height but on the other side, cables or connections *g h* proceeding from different points in the length of the girders *c d* and *e f* above mentioned to the top of the pier, and a counterweight arranged below the free end *f* of the girders *e f* secondly mentioned and connected to the said end substantially as and for the purpose set forth.

2. In a bridge, the combination with one part of a bridge comprising a pier *a b* erected on one bank, girders *c d* jointed at one of their ends *c* to one side of the pier at some distance from the top thereof, girders or beams *e f* mounted on the pier in the same manner as those first mentioned at the same height but on the other side, cables or connections *g h* proceeding from different points in the length of the above-mentioned girders *c d* and *e f* respectively to the top of the pier and a counterweight arranged below the free end *f* of the girders *e f* secondly mentioned and connected to the said end *f*, of a second bridge part jointed at one end to the free end *d* of the first-mentioned girders and means for supporting same on the other bank.

3. In a bridge, the combination with one part of a bridge comprising a pier *a b* erected on one bank, girders *c d* jointed at one of their ends *c* to one side of the pier at some distance from the top thereof, girders or beams *e f* mounted on the pier in the same manner as those first mentioned at the same height but on the other side, cables or connections *g h* proceeding from different points in the length of the girders *c d* and *e f* to the top of the pier and a counterweight arranged below the free end *f* of the girders *e f* secondly mentioned and connected to the said end of a second bridge part consisting of a bay 3 jointed at one end to the free end *d* of the first-mentioned girders and supported at the other end by a support erected on the other bank substantially as described and shown and for the purpose set forth.

4. In a bridge, the combination with one part of a bridge comprising a pier *a b* erected on one bank, girders *c d* jointed at one of their ends *c* to one side of the pier at some distance from the top thereof, girders *e f* mounted on the pier in the same manner as those first mentioned at the same height but on the opposite side, cables or connections *g h* proceeding from different points in the length of the above-mentioned girders *c d* and *e f* to the top of the pier, a counterweight arranged below the free end *f* of the girders *e f* secondly mentioned and connected to the said end and a second bridge part consisting of a bay 3 jointed at one end to the free end *f* of the girders *e f* and also supported at the other end by means of a joint connection to a support on the other bank, of the said support on the latter bank constructed like that on the first bank substantially as described and shown and for the purpose set forth.

In testimony that I claim the foregoing as my invention I have signed my name, in presence of two witnesses, this 7th day of June, 1901.

FERDINAND JOSEPH ARNODIN.

Witnesses:
EDWARD P. MACLEAN,
ALCIDE FABE.