Sept. 20, 1949. L. H. SHOEMAKER 2,482,562

VERTICAL LIFT BRIDGE

Filed May 22, 1945

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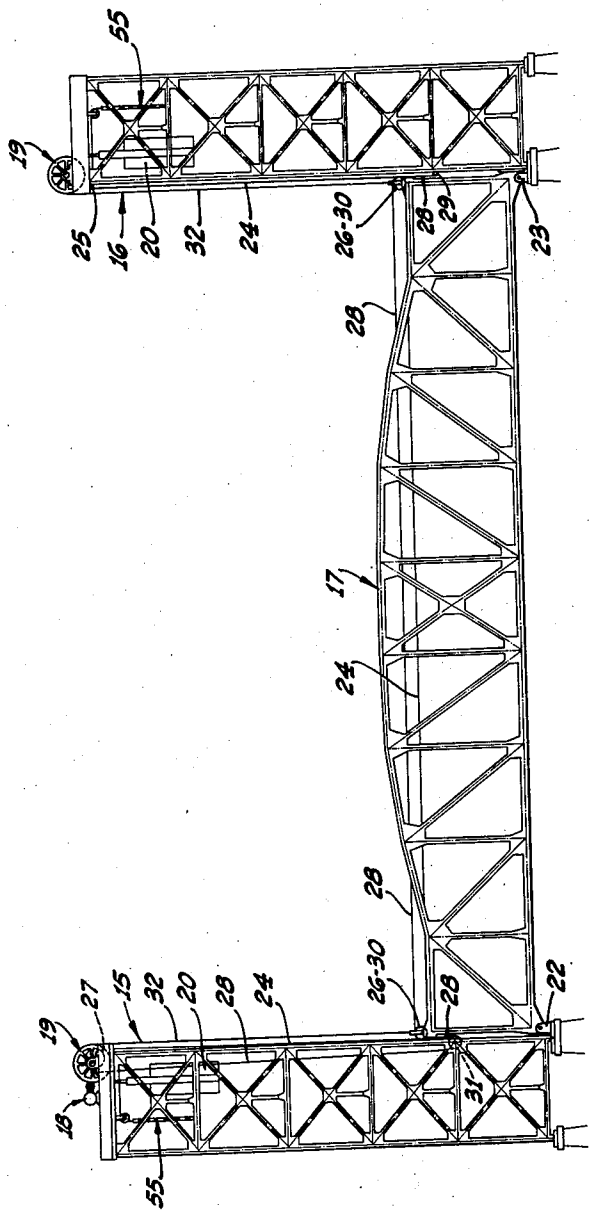


FIG. 1.

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VERTICAL LIFT BRIDGE

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5 Sheets-Sheet 2

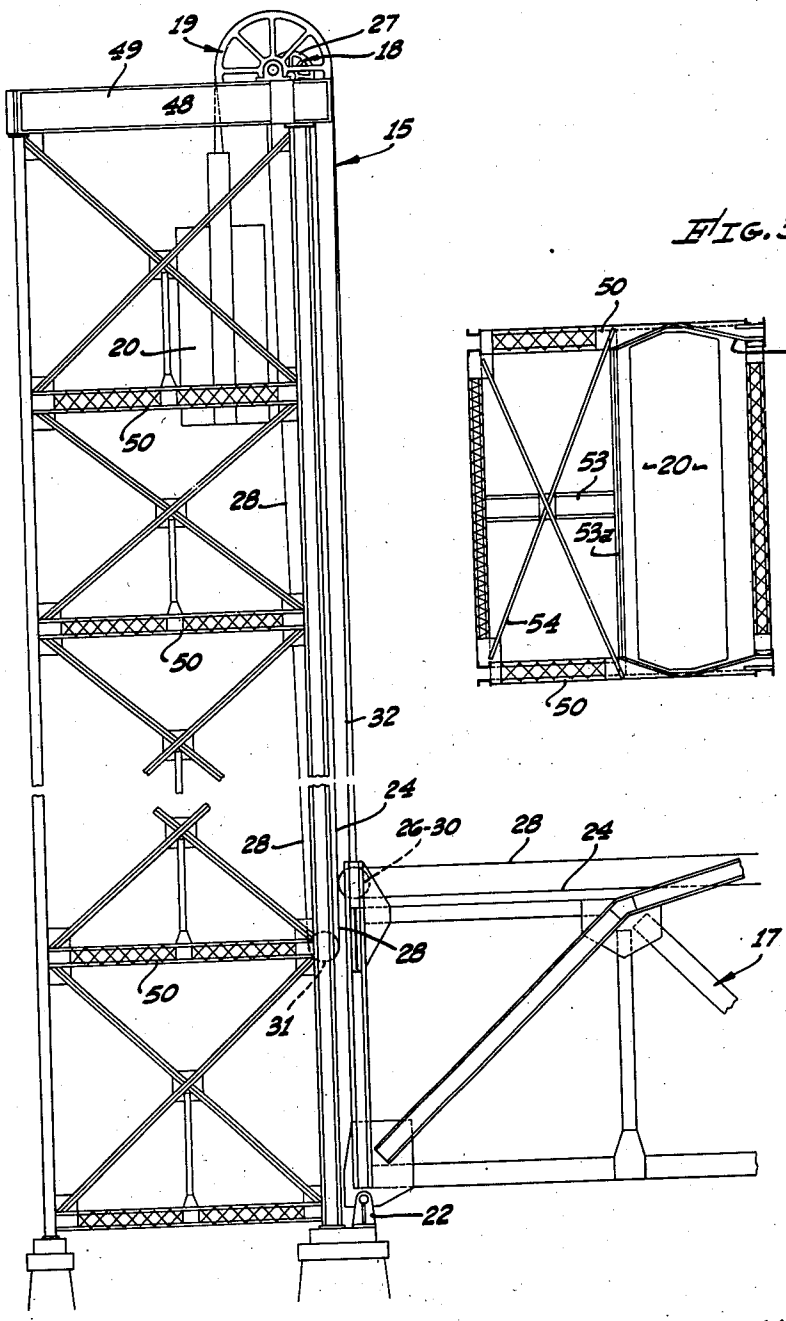


FIG. 2.

FIG. 3.

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VERTICAL LIFT BRIDGE

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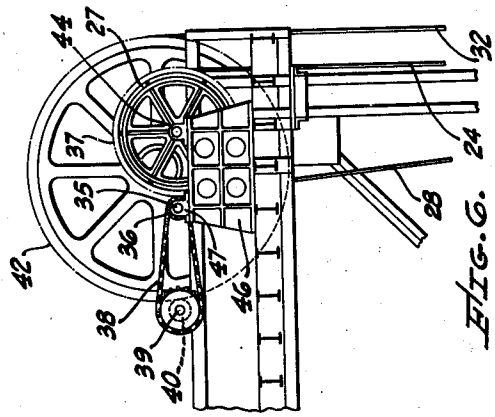


FIG. 6.

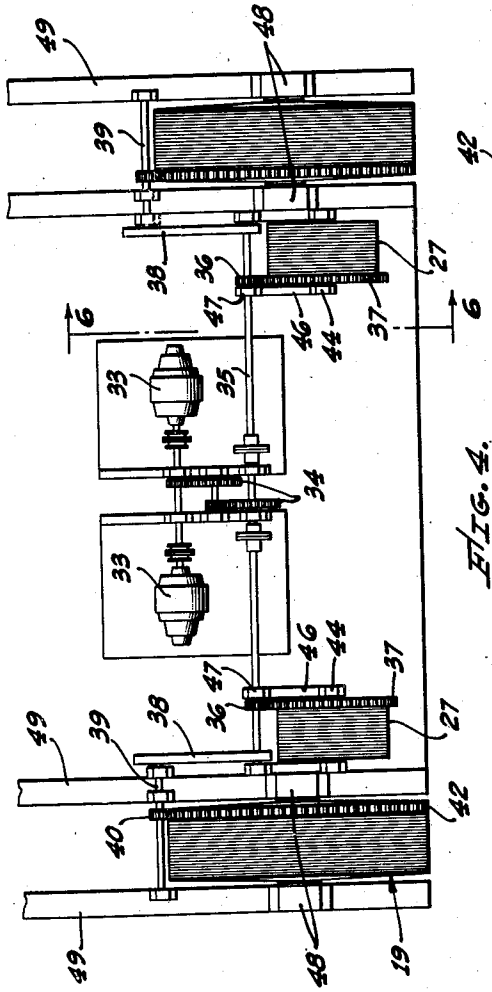


FIG. 4.

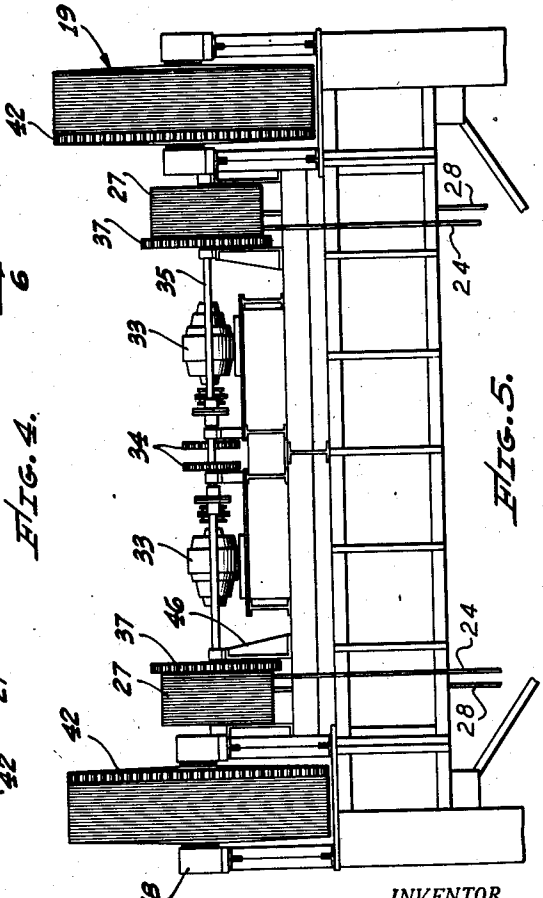


FIG. 5.

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VERTICAL LIFT BRIDGE

Filed May 22, 1945 5 Sheets-Sheet 4

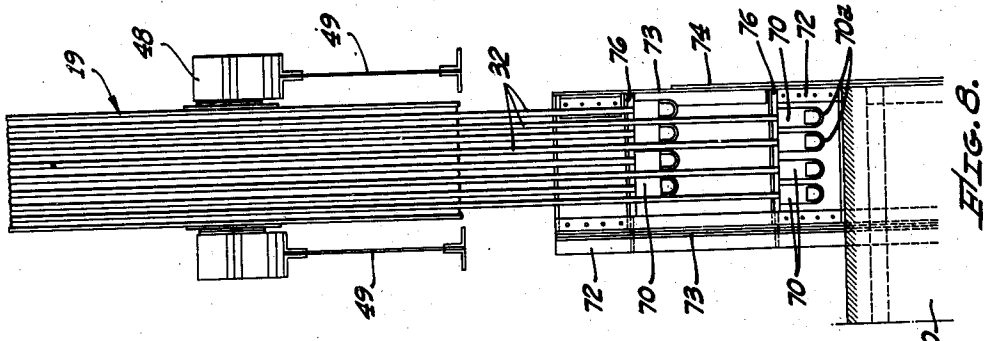


FIG. 8.

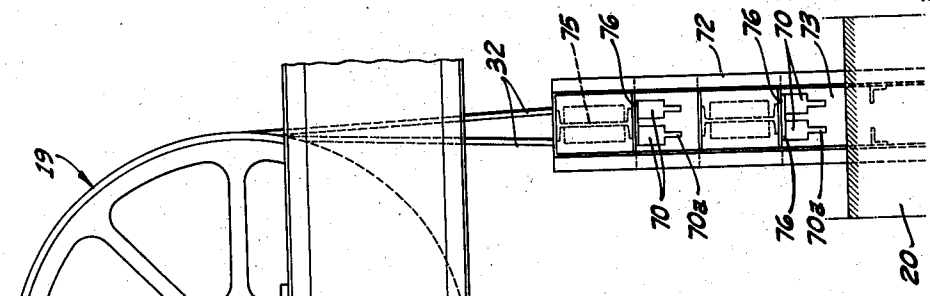


FIG. 7.

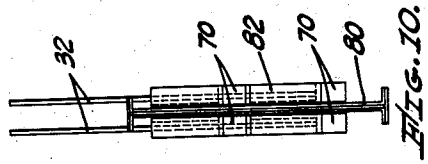


FIG. 10.

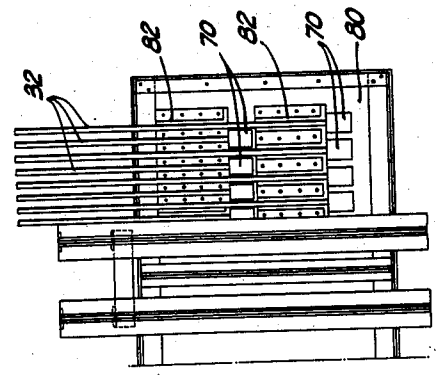


FIG. 9.

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Sept. 20, 1949. L. H. SHOEMAKER 2,482,562

VERTICAL LIFT BRIDGE

Filed May 22, 1945

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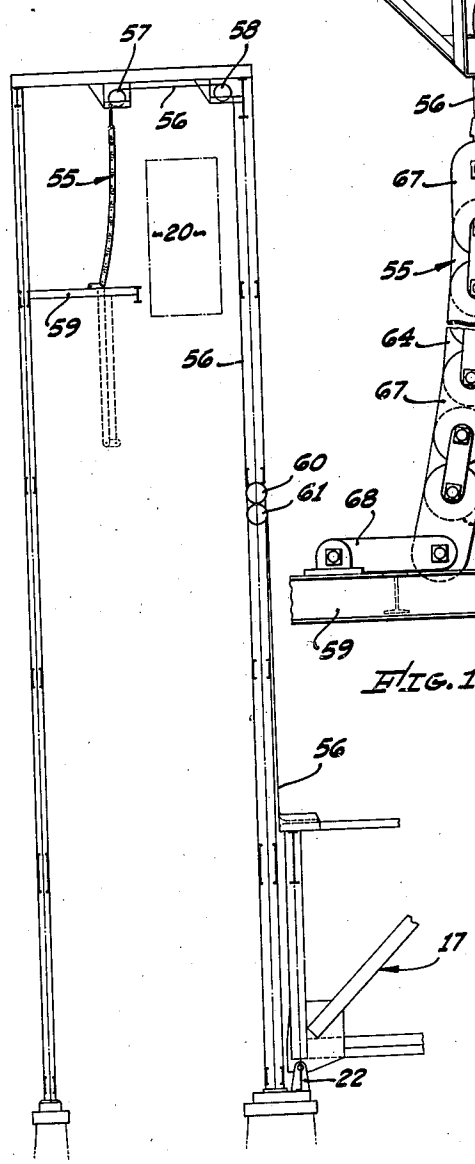


FIG. 11.

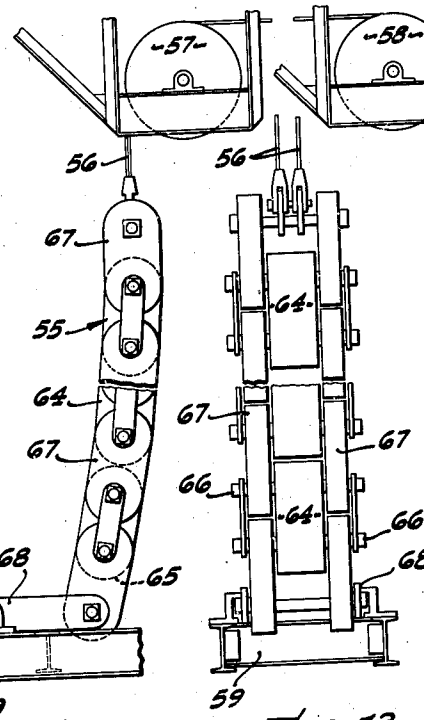


FIG. 12.

FIG. 13.

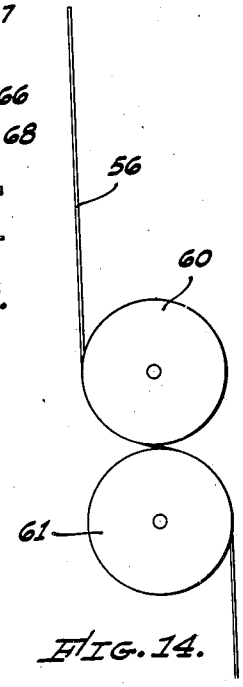


FIG. 14.

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Patented Sept. 20, 1949 2,482,562

UNITED STATES PATENT OFFICE

2,482,562

VERTICAL LIFT BRIDGE

Louis H. Shoemaker, Santa Monica, Calif; Security-First National Bank of Los Angeles, executor of said Louis H. Shoemaker, deceased

Application May 22, 1945, Serial No. 595,158

12 Claims. (Cl. 14—42)

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My invention relates to operating mechanism for bridges of the vertical lift span type, and also to a method of arranging the lifting and lowering cables and for assuring proper functioning of the mechanism.

At the present time vertical lift span bridges are operated principally by one or another of two different arrangements. In one, the operating power is mounted on the lifting span, while in the other the operating power is mounted on the towers at each side of the lifting span.

In the first case, the weight of the machinery with house and supports adds materially to the dead load on the lifting span and requires considerable increase of metal in the trusses. The power required to lift the span has, therefore, to be materially increased to provide for the additional load. If electric power is used, the current has to be carried onto the lifting span, involving further complication.

In the second case, two sets of machinery must be provided together with the necessary appliances for synchronizing the movement of the two ends of the span. In this type of operation electric power must be used, and the current carried across the opening to the farther tower. It is not possible to use gasoline or Diesel engines for auxiliary power in case of accident as the engines cannot be accurately synchronized.

It has also been proposed to provide means for raising the lifting span by cables operated by winding mechanism located on one tower, or on a shore span of the bridge adjacent the tower. In this proposed arrangement a plurality of sets of cables are employed connected to the corners of both ends of the bridge span, the lifting cables passing over sheaves arranged on the towers adjacent their points of attachment, under the bridge and over corresponding sheaves on the opposite tower, resulting in a somewhat complicated arrangement involving the use of long runs of cable.

One object of my invention is to provide a novel arrangement by means of which the vertically lifting span can be raised and lowered by power located on or near one of the towers at the ends of the span and utilizing a simple arrangement of cables, resulting in considerable reduction in dead weight and in improvement of operation.

Another object of the invention is to provide a single pair of lifting cables and a single pair of lowering cables effective to raise and lower both ends of the lifting span.

Another object of the invention is to provide means for insuring that the movement of the two

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ends of the lifting span will be uniform, in order to avoid faulty operation in raising the span and undesirable stresses in bringing the span back into contact with its supports.

Another object of the invention is to compensate in a novel manner for the varying load imposed on the raising and lowering machinery by the changes in length of the cables attached to the usual counterweights used in this type of lifting bridge during the raising and lowering of the span.

A further object of the invention is to provide improved means for attaching the ends of the cables to the loads carried, said means being adapted to the application of known forces by means of jacks or the like for the purpose of equalizing the load between the ropes of the cables.

A further object of the invention is to provide an improved type of the horizontal longitudinally extending frame members in the towers to permit counterweights of a more advantageous form to be used and enabling the girders supporting the counterweight sheaves to be positioned on the tops of the columns, thereby providing an improved arrangement of the counterweight and its supporting means.

Still further objects and features of the invention will appear in the following description taken in conjunction with the accompanying drawings.

In the drawings,

Fig. 1 is a side elevation showing a lifting span bridge having operating towers and cables arranged in accordance with my invention;

Fig. 2 is a side elevation to a larger scale than in Fig. 1, of the operating tower and a part of the adjoining end of the lifting span, certain parts being omitted for clarity;

Fig. 3 is a horizontal section showing the special construction of the longitudinally extending frame members bracing the towers with a counterweight in position;

Fig. 4 is a plan of the top of the operating tower showing the arrangement of the operating machinery;

Fig. 5 is a front elevation of the parts shown in Fig. 4;

Fig. 6 is a vertical section through the top of the operating tower on line 6—6, Fig. 4, showing the method of connecting the winding drums and counterweight sheave drives;

Fig. 7 is a fragmentary detail view showing the means of connection of the cables to the counterweights;

Fig. 8 is a view of the parts shown in Fig. 7 as seen from the right;

Fig. 9 is a fragmentary detail through the end of the lifting span showing the means of connecting the cables of the counterweights to the corners of each end of the span;

Fig. 10 is a view of the parts shown in Fig. 9, showing the parts as seen from the right;

Fig. 11 is a vertical section, with certain parts omitted, taken near the longitudinal center line of the towers, showing the location and method of operation of auxiliary chain counterweights for the main counterweight ropes;

Fig. 12 is a detail to a larger scale of the auxiliary chain counterweights;

Fig. 13 is a view of the parts shown in Fig. 12 as seen from the right; and

Fig. 14 is a detail view to a larger scale of the pull reversing sheaves of the auxiliary counterweights.

Referring now to Fig. 1, the general arrangement of the lifting span will be seen to comprise two vertical towers 15 and 16 and a vertically lifting span 17 which may be raised by cables between the towers, though the bridge is normally held resting on footings 22 and 23. It will be noted that the winding machinery 18 is, as shown, mounted on one tower only. Obviously the winding machinery may be positioned at any desired location on or adjacent one tower, but I prefer the location indicated. Sheaves 19 positioned on each tower are for the purpose of suspending counterweights 20. Preferably the counterweights substantially equal the total weight of the span so that the only power required is that necessary to overcome friction of the operating system of sheaves and cables. The span is normally held down upon footings 22 and 23 by a lowering cable as later described.

The tower 15 on which the winding drums are arranged will hereinafter be referred to as the "operating tower" and the other tower 16 will be referred to as the "idler tower." The bridge span is lifted or raised by a cable 24 for each side secured toward the top of the idler tower as indicated at 25 and passed under sheaves 26 which may conveniently be mounted at the upper corners of the span, when constructed as illustrated, at each end thereof. The cables 24 pass underneath the sheaves 26 at the opposite end of the span and extend upwardly to the top of the operating tower and are secured to the winding drums 27 mounted on the top thereof.

By mounting the winding machinery on the tower a minimum length of cable is required with a consequent saving in associated parts such as sheaves, thus reducing weight, and also reducing to a minimum the frictional losses which are considerable in wire cables working over sheaves.

The cables 28 used for lowering the bridge are secured to the idler tower towards the foot thereof as indicated at 29, passed over sheaves 30 conveniently arranged at the same approximate location as the lifting sheaves, carried across the bridge and over sheaves 30 at the opposite end thereof, taken down to pass under sheaves 31, and carried upwardly for attachment to the winding drum 27, the cables being laid around the winding drum so that as the lifting cable 24 is taken in the lowering cable is played out and vice versa. One lifting and one lowering cable is provided for each side of the bridge span.

Cables for raising and lowering the lifting span of bridges are usually doubled for safety reasons, but for convenience I have described the use of single control cables.

The main counterweight cables 32 are attached to the upper corners of the overhead structure of the lifting span at each end thereof.

It will be obvious that as the lifting cables are wound on the drum the lifting span will be vertically raised but it is possible for one end of the bridge, usually that away from the operating tower, to lag the other unless means are taken to insure that both ends of the bridge move upwardly at the same speed. For this purpose I provide means for connecting the counterweight sheave to the bridge winding drum to insure that the counterweight in the operating tower moves at a coordinated speed to that of the winding drum. This arrangement effects the desired purpose of causing equal movement of both ends of the span.

Figs. 4 and 6 show the operating means for the winding drums for each side of the lifting span and the drive connection between the counterweight sheaves and the winding drums. Electric motors 33, of the reversible type or fitted with a reverse gear, act through change speed gearing 34, drive the main drive shaft 35, which is arranged to drive the winding drums 27 on the operating tower through spur gears 36 and large gears 37 mounted on the rim of each drum. A chain drive 38 at each end of shaft 35 drives a countershaft 39 carrying a spur gear 40. This latter gear drives counterweight sheave 19 through the medium of gear 42 thereon. The gears are so proportioned as to effectively drive the cables passing over the drums 27 at twice the speed of the cables passing over the counterweight sheaves 19. It is contemplated, of course, that movement of the counterweight be coordinated with the movement of the lifting span and hence the ratio or relative speed of the winding drums and counterweight sheaves would vary for different systems of stringing the lifting lines. It would also vary with different diameters of winding drums and counterweight sheaves.

While various arrangements may be provided of the relative positions of the sheaves for the counterweights and for the raising and lowering drums of the lifting span, that preferred by me and illustrated in detail in Figs. 4, 5 and 6, comprises bearings 44 for the shafts of the winding drums 27 mounted on a built-up bearing block 46 also carrying bearings 47 for the main drive shaft 35. The bearings 48 for the counterweight sheave shafts are carried on girders 49 extending across the top of the tower, the outside girder on each side being supported on the tops of the vertical columns at the front and rear corners of the towers at that side, as permitted by the extra width of the counterweight provided by my construction thereof.

Fig. 3 shows in detail the arrangement of the longitudinal horizontal structural members 50 bracing the towers which are arranged to enable a form of counterweight to be used which permits various advantages to be secured in the construction of the tower. It will be seen that the width of the longitudinally extending bracing members toward the front of the tower is concavely inclined at 52 toward the counterweight 20 to enable a counterweight to be used which is substantially the full width of the tower, thus enabling the counterweight sheaves to be supported as above described. All diagonal bracing of the sides of the tower is positioned on the outer sides only and to provide additional stiff-

ness to compensate for the reduction in width of the longitudinally extending bracing, I provide horizontal struts 53 and 53a and cross braces 54.

The single sets of cables 32 for the counterweights at each end of the span have to carry half the weight of the span, and therefore their weight is very considerable. In the lowered position of the span the weight of the cables is carried on the span side of the towers, thereby increasing the weight to be lifted by the winding engines, whereas in the raised position of the span the weight of the cables is suspended from the counterweight sheave on the opposite side, thereby decreasing the weight to be lifted. The increase in the effective weight of the counterweight tends to cause increasingly rapid lifting of the span unless guarded against.

A feature of my invention is to compensate for the varying load caused by the counterweight cables by the provision of a short length of chain 55, serving as an auxiliary counterweight, which, instead of being lowered between extreme high and low positions of the counterweight as in known constructions, is moved through only one-fourth this distance and at the fully raised position of the lifting span is in fully raised position. The construction and operation of the auxiliary counterweights is shown in Figs. 11, 12, 13 and 14. The weight of chain 55 is nearly as possible equal to the total weight of the wire cables passing over the sheaves from the lifting span. The chain is attached to a top member of the lifting span by means of a cable 56 passing over a sheave 57 supported on the towers and over a second sheave 58 enabling the chain to hang downwardly with the bottom link supported on an abutment 59 arranged at a point one-quarter of the distance traveled by the main counterweight between its raised position and its lowered position.

At a point exactly midway of the travel of the lifting span of the bridge two sheaves 60, 61 are arranged in vertical relation and are spaced apart as closely as is possible while permitting travel between them of the cable supporting the auxiliary counterweight chain. The upper portion of the vertical run of the chain supporting cable passes around the tower side of the upper sheave, then passes between the sheaves, and continues over the opposite side of the lower sheave to its point of connection to the lifting span. The result of this arrangement is that during the raising of the lifting span, the top of the chain is lowered, thus continuously reducing the weight of the chain suspended by the cable as more and more of the chain is suspended from the abutment, until the point of attachment of the chain to the lifting span reaches the level at which the cable passes between the vertically arranged sheaves, at which time the weight of the auxiliary chain counterweight is wholly suspended from the abutment exactly compensating for the increased weight of the counterweight cable in the tower. As the point of attachment of the cable of the auxiliary counterweight passes the vertically arranged sheaves, the upper sheave acts to transmit a pull to the cable which acts against the lifting power and again raises the end of the chain or auxiliary counterweight so that in the fully raised position of the vertically lifting span the chain is suspended by its attaching cable from the lifting span, thus the extra weight added to the counterweight by the counterweight cables is counterbalanced at all times.

To provide a chain which will function satisfactorily I construct it of a plurality of short rectangular sections 64 of cast iron or other suitable material, as shown in detail in Figs. 12 and 13. These sections have rounded ends 65 to enable them to move relatively to one another, and are connected by pins 66 passing through side links 67 which are of similar form to the sections 64 except that they are each of half the thickness of the sections. The last upper link is connected to the cable 56, which is preferably double, while the lowest link is connected to spacing members 68 pivoted in bearings on the abutment 59 and acting to hold the length of chain clear of the abutment so that it may be lowered by cable 59 link by link until wholly supported on the abutment.

A still further feature of the invention is the provision of novel attaching means for the ends of the cables. It has previously been necessary to spread the ends of a set of cables raising heavy loads over sheaves and this has resulted in a somewhat cumbersome arrangement of anchoring means. In order to economize space in the anchoring of a number of cable ends, I arrange the cable ends in sockets 70 (Figs. 7 and 8) of square cross section of relatively small size and provide abutments for these sockets arranged in vertical tiers, the cables attached to a tier passing between the sockets of a higher tier. By this means a large number of cable ends can be secured to a smaller area of anchor plate and occupy a smaller volume than has been possible by previous practice.

Preferably the sockets are provided with eyes 70a. A pin may be passed through two opposite eyes and the end of a lever, fulcrumed against the structure, may be passed over the pin, a hydraulic jack being used bearing against the free end of the lever to stress the cables to their proper load, any slack being taken up by shims inserted between the sockets and their abutment.

Figs. 7 and 8 show the connection of the counterweight cables 32 to the counterweights 20 which are formed about a structural frame to which lengths of angle material 72 are riveted and which project from the upper surface of the counterweight toward each end thereof. Plates 73 are secured to the flanges of the angle material and to a heavy strap 74 extending vertically from the outside edge of the counterweight and secured to its structure and lengths of I beam 75 are arranged to extend between the plates 73 and are secured thereto by angles. Plates 76 of heavy gauge are welded to the lower surface of the bottom flange of the I beams to provide abutments for the upper surfaces of the square sockets 70. The cables 32 are positioned in slots formed in the plates and I beams. Sixteen cable ends are shown arranged in two tiers with half the cable ends on one side of the webbs of the I beams and half on the opposite side. It will be noted that the construction described provides a very compact cable end anchoring assembly.

Figs. 9 and 10 show the right hand half of an arrangement for connecting the counterweight cable ends to the end of the lifting span. An I beam 80 is arranged to extend across the ends of the span superstructure to which it is secured, and special castings 82 are bolted to the front and back of the webb at each side of the bridge. The casting 82 is formed to provide channels for the cables and flanges against which bear the square section cable end fittings. The cable ends at each side of the bridge are arranged in tiers and to the back and front of the carrying beam as in the construction shown in Figs. 7 and 8.

It will be evident that I have provided a vertical lifting span bridge in which the lifting and operating means are simple, effective, and economical to construct and operate; however, various modifications of the described arrangements may be made without departing from the scope of the invention as indicated by the appended claims.

I claim:

1. A vertical lifting span bridge including: an operating tower; an idler tower; a vertical lift span arranged for upward and downward movement between said towers; sheaves mounted on said towers at each side thereof; bearing members for said sheaves, one of said bearing members at each side being in the plane of a side of the tower and near a vertical column thereof; horizontal longitudinally extending tower bracing members reduced in width in a part of their length; additional horizontal internal tower bracing members compensating for the reduced width of said longitudinally extending members; diagonally arranged tower cross bracing members arranged on the exterior of said tower; a counterweight extending across substantially the full width of the tower interior in the space provided by the reduction in width of the longitudinally extending bracing members; cables secured to said counterweight passed over said sheaves and secured to said lifting span; lifting cable means secured at one end to the idler tower; lowering cable means secured at one end to the idler tower; sheaves mounted on the vertical lift span around which the lifting and lowering cable means are passed; cable winding means located off the lifting span adjacent one end only thereof; sheaves mounted on the operating tower below the level of the sheaves on said lifting span when said span is in lowered position and around which the lowering cables are passed from the lifting span and led to the winding means, said lifting and lowering cables being secured to said winding means so that operation of said winding means acts, according to the direction of rotation thereof, to raise or lower said span.

2. A vertical lifting span bridge including: an operating tower; an idler tower; a vertical lift span arranged for upward and downward movement between said towers; sheaves mounted on said towers; bearing members for said sheaves, one of said bearing members at each side being in the plane of a side of the tower and near a vertical column thereof; horizontal longitudinally extending tower bracing members reduced in width in a part of their length; additional horizontal internal tower bracing members compensating for the reduced width of said longitudinally extending members; diagonally arranged tower cross bracing members arranged on the exterior of said tower; a counterweight extending across substantially the full width of the tower interior in the space provided by the reduction in width of the longitudinally extending bracing members; and cables secured to said counterweight passed over said sheaves and secured to said lifting span.

3. A vertical lifting span bridge including: an operating tower; an idler tower; a vertical lift span arranged for upward and downward movement between said towers; counterweight sheaves mounted on said towers; cables attached to said lifting span and extending over said sheaves; counterweights suspended in said towers from said cables; auxiliary counterweight sheaves mounted on said towers; auxiliary counterweight supporting cables running over said auxiliary counterweight sheaves and attached to said span; auxiliary counterweights of variable effective weight suspended in said towers from the cables running over said auxiliary counterweight sheaves and comprising a plurality of connected bodies for counterbalancing the weight of the counterweight cables; means for changing the direction of movement of the auxiliary counterweight supporting cables during one-half of the upward or downward movement of said span; an abutment arranged on each of the towers to engage with the lowermost of said connected bodies of said auxiliary counterweights; cable means attached to the idler tower for raising and lowering said span; sheaves mounted on the lifting span; sheave means mounted on said operating tower below the level of the sheaves on said lifting span when said span is in lowered position of the lifting span; and cable winding means located off the lifting span adjacent one end only thereof, said cable means being passed from the points of attachment to the idler tower around the sheaves on the lifting span and around the sheave means mounted on the operating tower therebelow and engaged with said winding means, so that operation of said winding means acts, according to the direction of rotation thereof, to raise or lower the lifting span.

4. A vertical lifting span bridge including: an operating tower; an idler tower; a vertical lift span arranged for upward and downward movement between said towers; counterweight sheaves mounted on said towers; cables attached to said lifting span and extending over said sheaves; counterweights suspended in said towers from said cables; auxiliary counterweight sheaves mounted on said towers; auxiliary counterweight supporting cables running over said auxiliary counterweight sheaves and attached to said lifting span; auxiliary counterweights of variable effective weight suspended in said towers from the cables running over said auxiliary counterweight sheaves and comprising a plurality of connected bodies; means for changing the direction of movement of the auxiliary counterweight supporting cables during one-half of the upward or downward movement of said span; means to vary the weight of said auxiliary counterweight acting through its supporting cable on said lifting span; cable means attached to the idler tower for raising and lowering said span; sheaves mounted on the lifting span; sheave means mounted on said operating tower below the level of the sheaves on said lifting span when said span is in lowered position; and cable winding means located off the lifting span adjacent one end only thereof, said cable means being passed from the points of attachment to the idler tower around the sheaves on the lifting span and around the sheave means mounted on the operating tower therebelow and engaged with said winding means, so that operation of said winding means acts, according to the direction of rotation thereof, to raise or lower the lifting span.

5. A vertical lifting span bridge including: an operating tower; an idler tower; a vertical lift span arranged for upward and downward movement between said towers; cable means attached to the idler tower for raising and lowering said span; sheaves mounted on the lifting span; sheave means mounted on said operating tower below the level of the sheaves on said lifting span when said span is in lowered position; cable winding means located off the lifting span adjacent one

end only thereof, said cable means being passed from the points of attachment to the idler tower around the sheaves and sheave means and engaged with said winding means, so that operation of said winding means acts, according to the direction of rotation thereof, to raise or lower the lifting span; counterweight sheaves on said towers; main counterweight cables attached to the lifting span and passing over said counterweight sheaves; main counterweights suspended from said counterweight cables; and means connecting the cable winding means and certain counterweight sheaves to insure a desired ratio of relative speed of rotation of said winding means and counterweight sheaves to effect level raising of said vertical lifting span.

6. A vertical lifting span bridge including: an operating tower; an idler tower; a vertical lift span arranged for upward and downward movement between said towers; a pair of lifting cable means secured at one end to the idler tower for raising each side of the span; a pair of lowering cables means secured at one end to the idler tower for lowering each side of the span; sheaves mounted on the vertical lift span around which the lifting and lowering cable means are passed; cable winding means located on the operating tower; sheaves mounted on the operating tower below the level of the sheaves on said lifting span when said span is in lowered position and around which the lowering cables are passed from the lifting span and led to the cable winding means, said lifting and lowering cables being secured to said winding means so that operation of said winding means acts, according to the direction of rotation thereof, to raise or lower said span; counterweight sheaves on said towers; main counterweight cables attached to the lifting span and passing over said counterweight sheaves; main counterweights suspended from said counterweight cables; and means connecting the cable winding means on the operating tower and the counterweight sheaves thereon to insure a desired ratio of relative speed of rotation of said winding means and counterweight sheaves to effect level raising of said vertical lifting span.

7. A vertical lifting span bridge including: an operating tower; an idler tower; a vertical lift span arranged for upward and downward movement between said towers; counterweight sheaves mounted on said towers; cables attached to said lifting span and extending over said sheaves; counterweights suspended in said towers from said cables; auxiliary counterweight sheaves mounted on said towers; auxiliary counterweight supporting cables running over said auxiliary counterweight sheaves and attached to said lifting span; auxiliary counterweights suspended in said towers from the cables running over said auxiliary counterweight sheaves and comprising a plurality of connected bodies for counterbalancing the weight of the counterweight cables; means for changing the direction of movement of the auxiliary counterweight supporting cables during one-half of the upward or downward movement of said span; an abutment arranged on each of the towers to engage with the lowermost of said connected bodies of said auxiliary counterweight; lifting cable means attached to the idler tower for raising and lowering said span; sheaves mounted on the lifting span; sheave means on said operating tower below the level of the sheaves on the lifting span when said span is in lowered position; cable winding means located on said operating tower; said lifting cable means being passed from the points of attachment to the idler tower around the sheaves on said lifting span and said sheave means on said operating tower and engaged with said winding means, so that operation of said winding means acts, according to the direction of rotation thereof, to raise or lower the lifting span; and means connecting the cable winding means on the operating tower and the counterweight sheaves thereon to insure a desired ratio of relative speed of rotation of said winding means and counterweights to effect level raising of said vertical lifting span.

8. A vertical lifting span bridge including: an operating tower; an idler tower; a vertical lift span arranged for upward and downward movement between said towers; cable means attached to the idler tower for raising and lowering said span; sheaves mounted on the lifting span; sheave means mounted on said operating tower below the level of the sheaves on the lifting span when said span is in lowered position of the lifting span; cable winding means located on the operating tower, said cable means being passed from the points of attachment to the idler tower around the sheaves and sheave means and engaged with said winding means, so that operation of said winding means acts, according to the direction of rotation thereof, to raise or lower the lifting span; counterweight sheaves on said towers; main counterweight cables attached to the lifting span and passing over said sheaves; main counterweights suspended from said counterweight cables; shelf-like abutments arranged on said lifting span and said counterweight; rectangular sockets in which said main counterweight cable ends are secured, said rectangular sockets being arranged in close proximity to one another to engage the undersurface of said abutments; and means connecting the cable winding means on the operating tower and the counterweight sheaves thereon to insure a desired ratio of relative speed of rotation of said winding means and counterweight to effect level raising of said vertical lifting span.

9. A vertical lifting span bridge including: an operating tower; an idler tower; a vertical lift span arranged for upward and downward movement between said towers; cable means attached to the idler tower for raising and lowering said span; sheaves mounted on the lifting span; sheave means mounted on said operating tower below the level of the sheaves on the lifting span when said span is in lowered position; cable winding means located off the lifting span adjacent one end only thereof, said cable means being passed from the points of attachment to the idler tower around the sheaves and sheave means and engaged with said winding means, so that operation of said winding means acts, according to the direction of rotation thereof, to raise or lower the lifting span; counterweight sheaves on said towers; main counterweight cables attached to the lifting span and passing over said counterweight sheaves; main counterweights suspended from said counterweight cables; and means for insuring equal rate of movement of the ends of the lifting span comprising a mechanical drive means connecting said cable winding means and said counterweight sheaves.

10. In a vertical lifting span bridge, an operating tower; an idler tower; a vertical lift span arranged for upward and downward movement between said towers; counterweight sheaves mounted on said towers; cables attached to said

lifting span and extending over said sheaves; counterweights suspended in said towers from said cables; auxiliary counterweight sheaves mounted on said towers; auxiliary counterweight supporting cables running over said auxiliary counterweight sheaves and attached to said span; auxiliary counterweights of variable effective weight suspended in said towers from said auxiliary counterweight supporting cables, said auxiliary counterweights each comprising an elongated flexible member; means in the towers for supporting said auxiliary counterweights at the ends thereof opposite to the ends supported by the auxiliary counterweight supporting cables; and means for changing the direction of movement of the auxiliary counterweight supporting cables during one-half of the upward or downward movement of said span.

11. A bridge as defined in claim 10 in which the means for changing the direction of movement of the auxiliary counterweight supporting cables during one-half of the upward or downward movement of said span comprises a pair of sheaves for each of said auxiliary counterweight supporting cables mounted on said towers at a point halfway between the uppermost and lowermost positions of said span, said auxiliary counterweight supporting cables running from said span between said pairs of sheaves to said auxiliary counterweight sheaves.

12. In a vertical lifting span bridge, an operating tower; an idler tower; a vertical lift span arranged for upward and downward movement between said towers; counterweight sheaves on said towers; counterweight cables passing over said sheaves and attached to the lifting span; counterweight suspended in said towers from said counterweight cables; cable and sheave means mounted on said towers and said lifting span for effecting raising and lowering of said span; and means for insuring equal rate of movement of the ends of the lifting span comprising a driving connection between said cable and sheave means for raising and lowering the span and said counterweight sheaves for driving said counterweight sheaves at a desired speed of rotation relative to the speed of said sheave and cable means.

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