Sept. 16, 1930. E. F. W. ALEXANDERSON 1,775,801
RADIO SIGNALING SYSTEM
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Fig. 1.

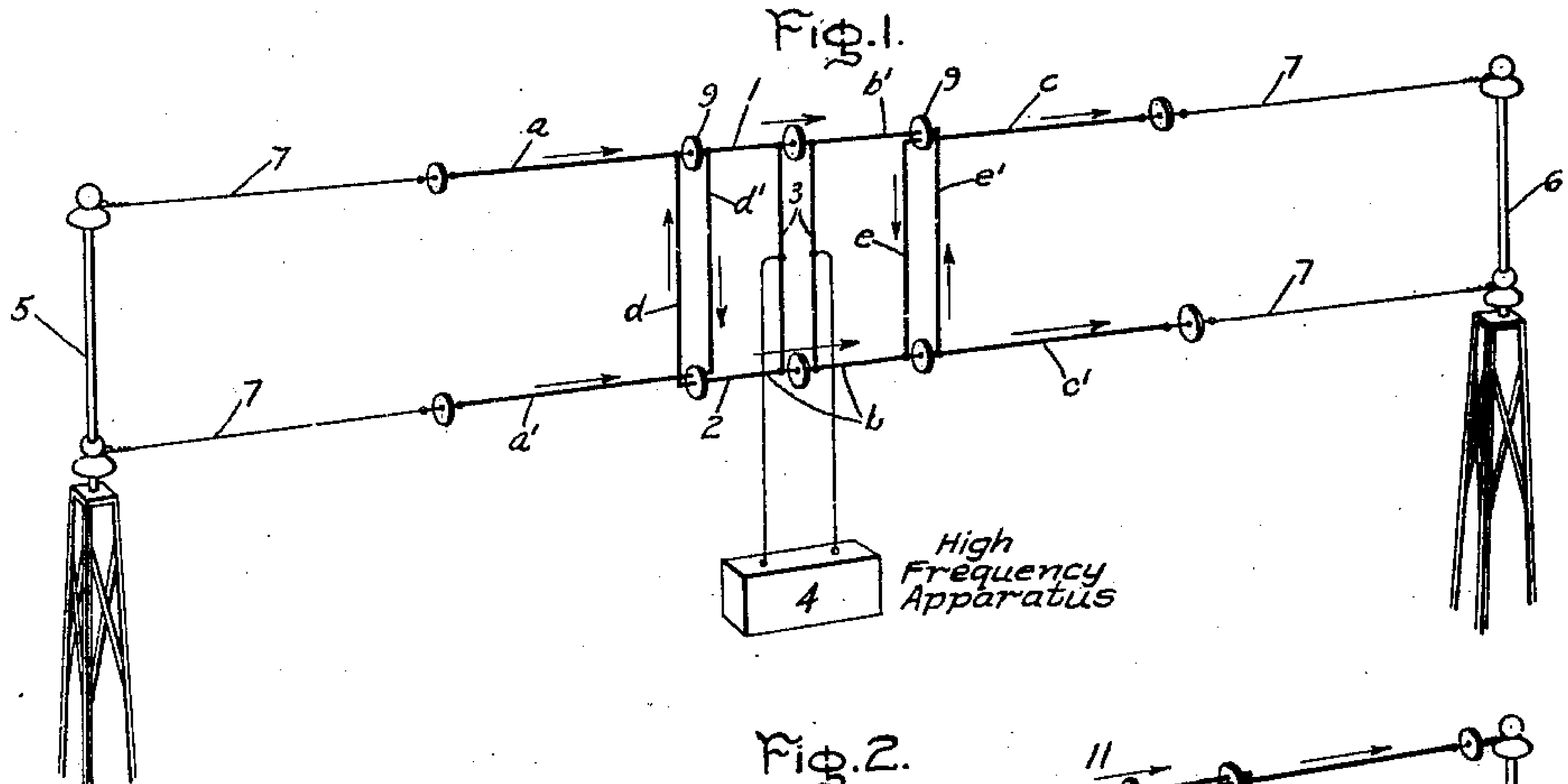

Fig. 2.

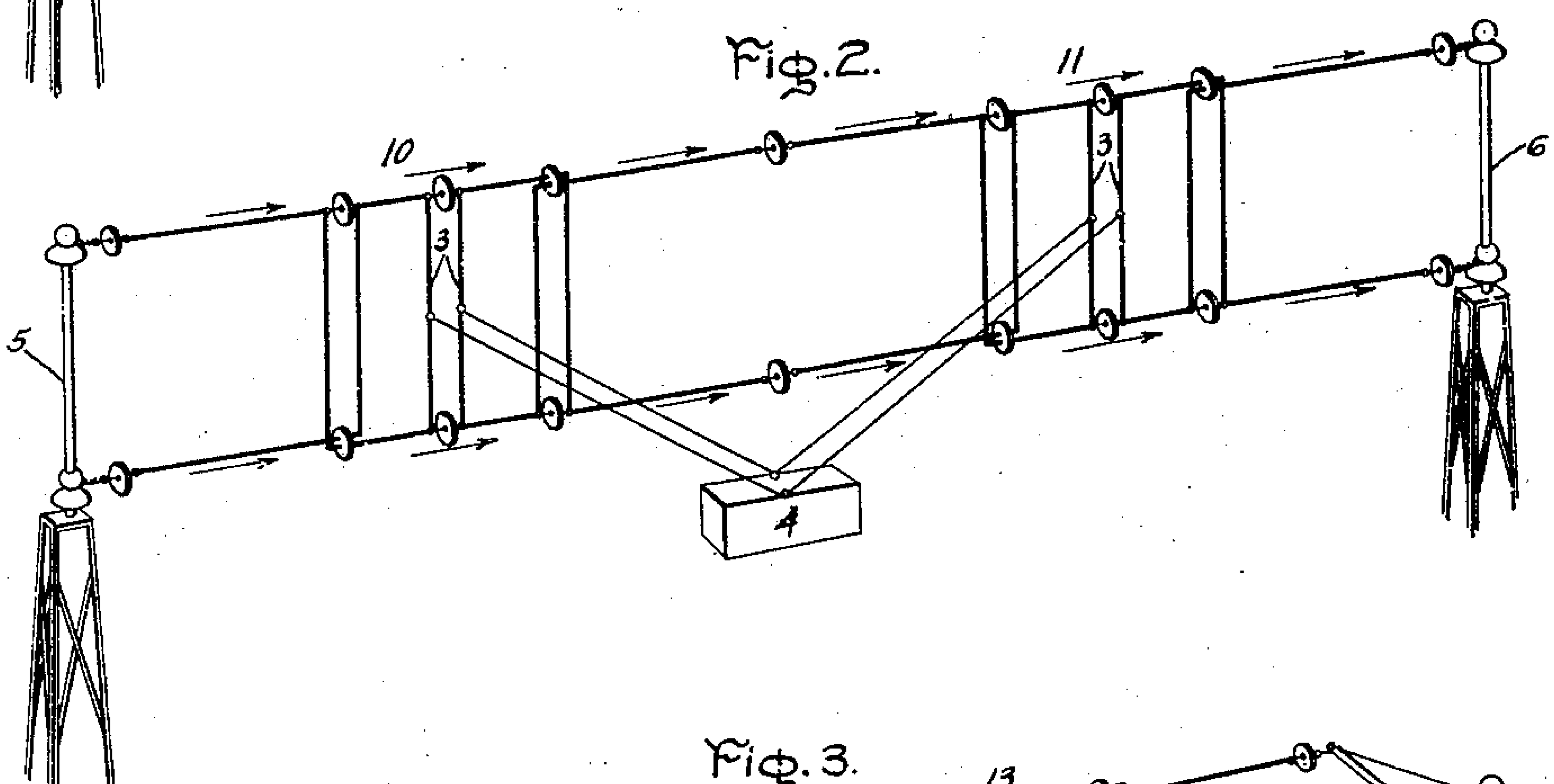

Fig. 3.

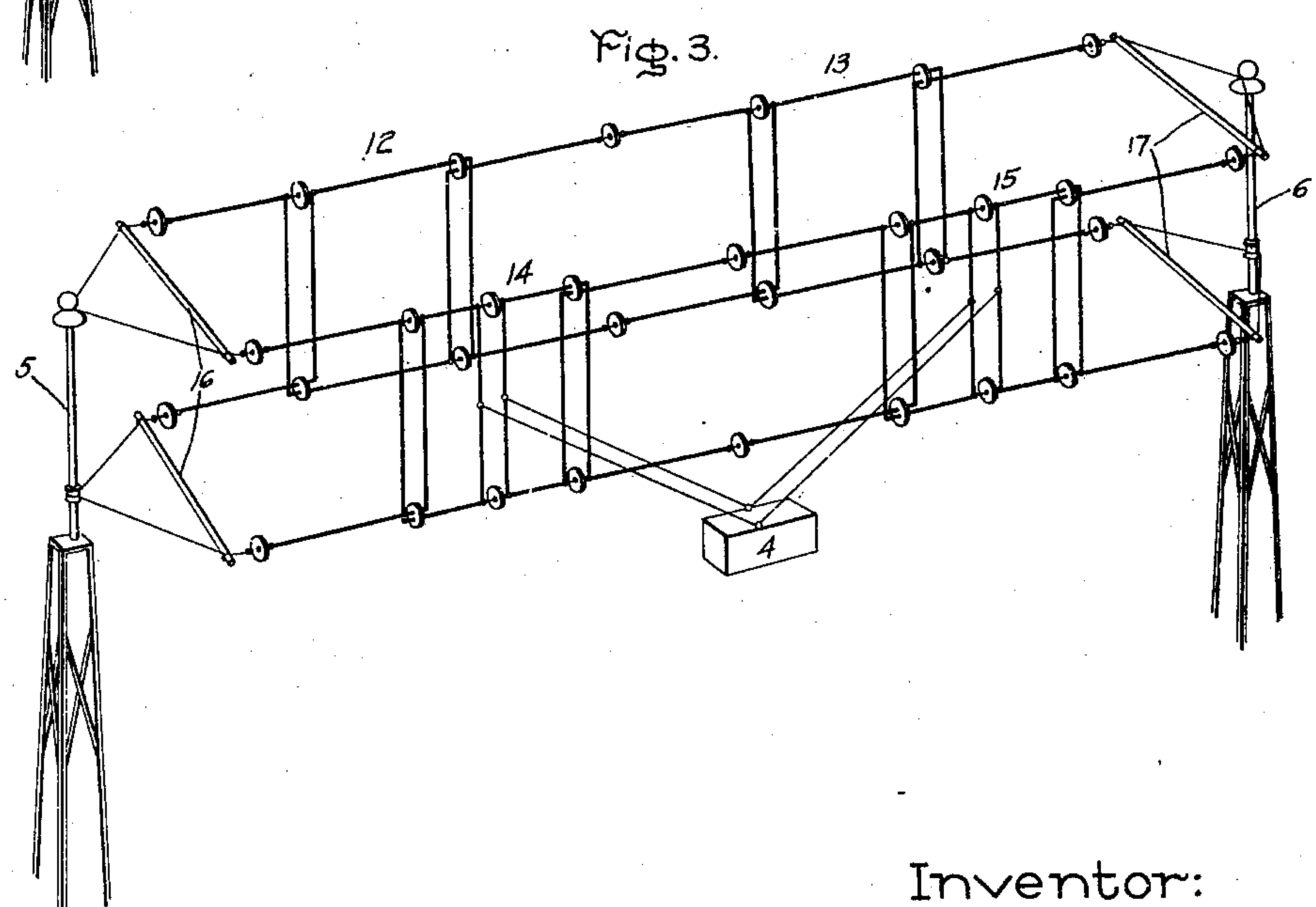

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Fig. 4.

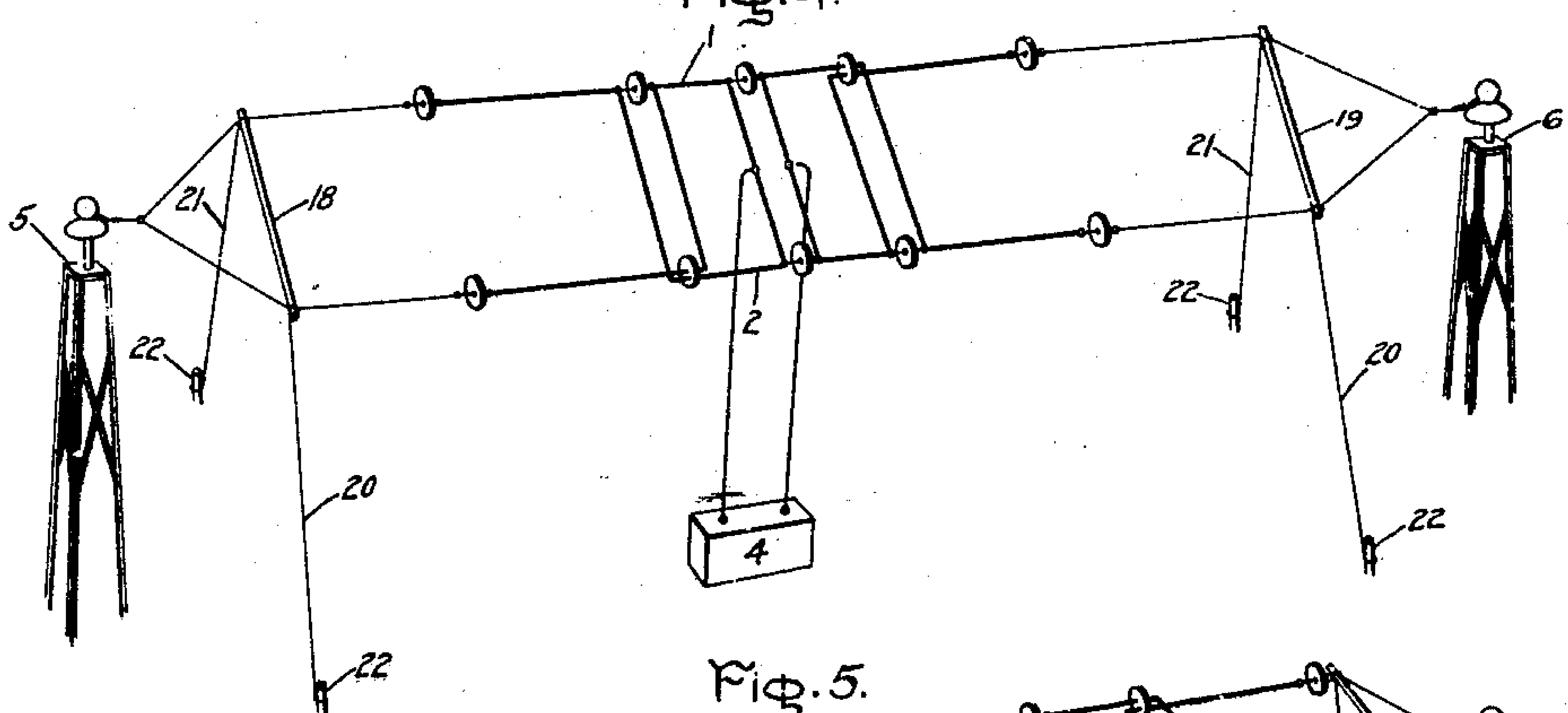

Fig. 5.

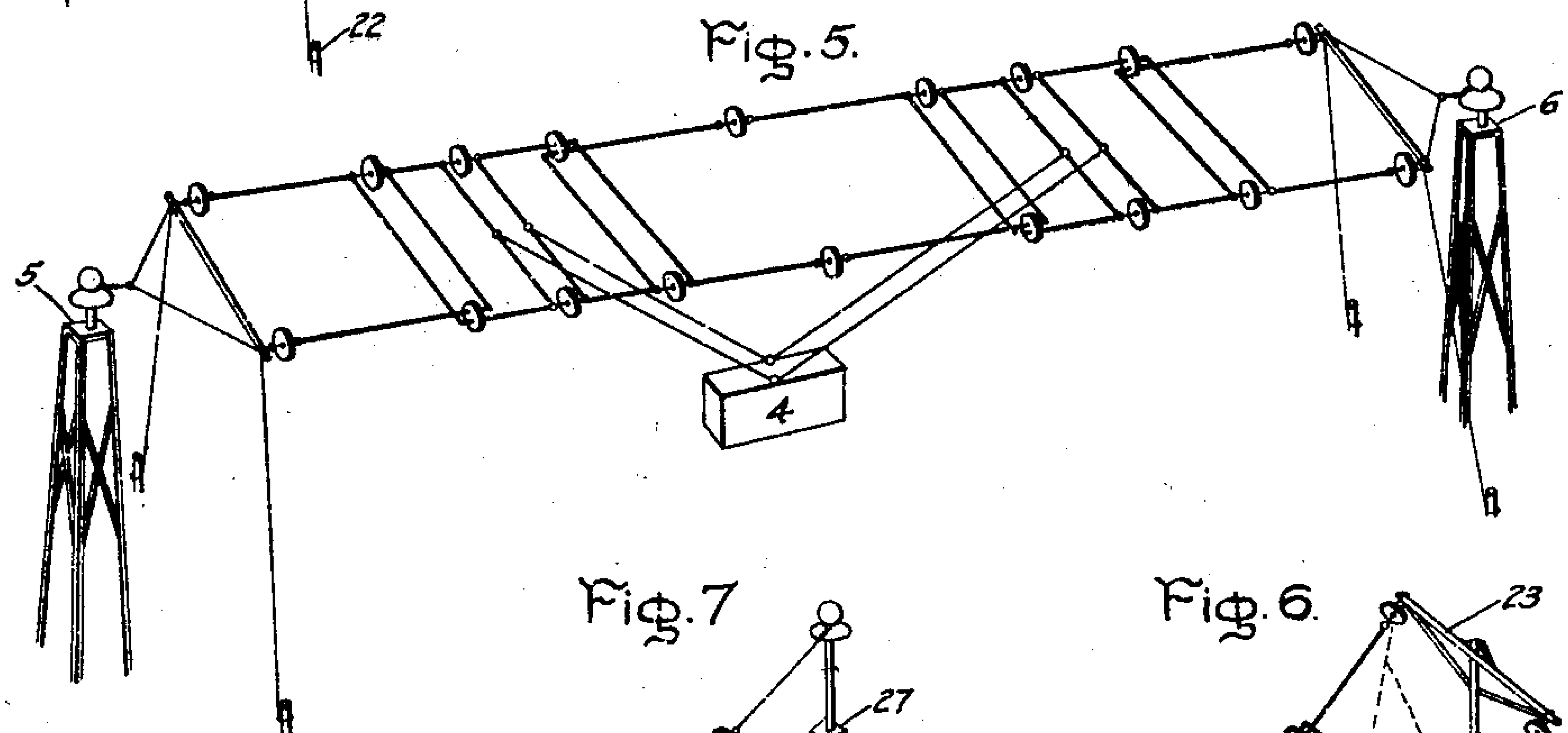

Fig. 7

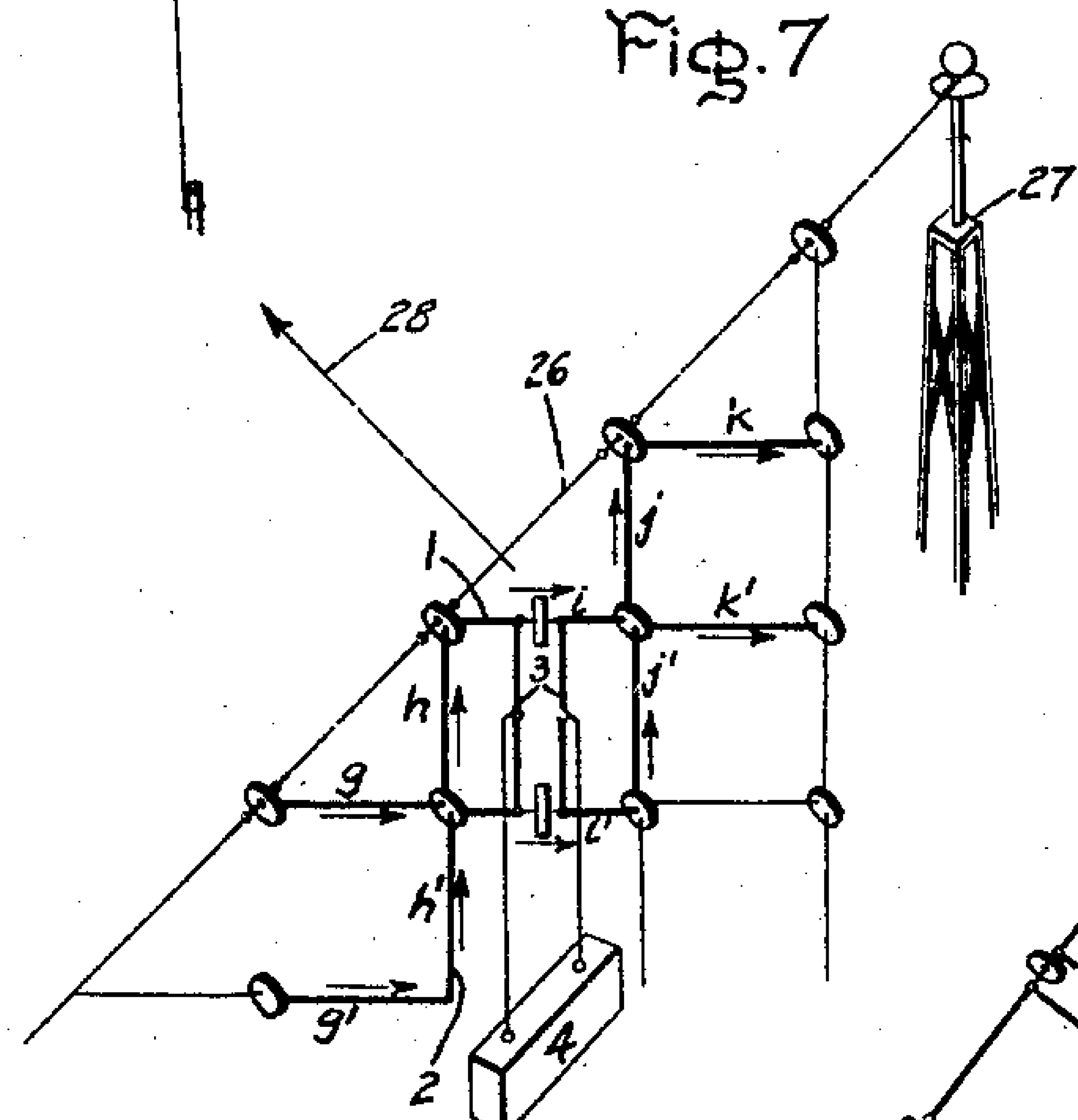

Fig. 6.

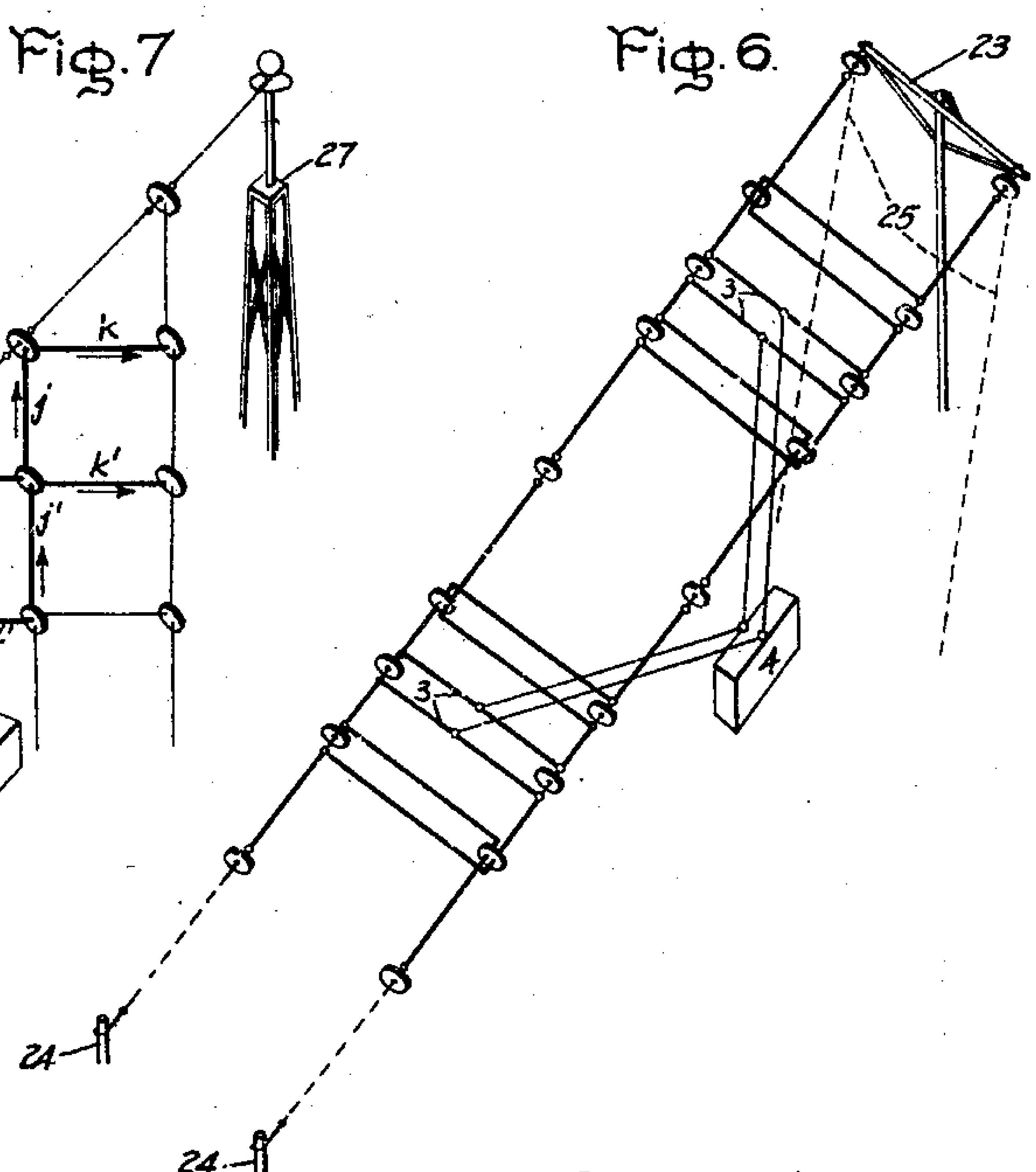

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Fig. 8.

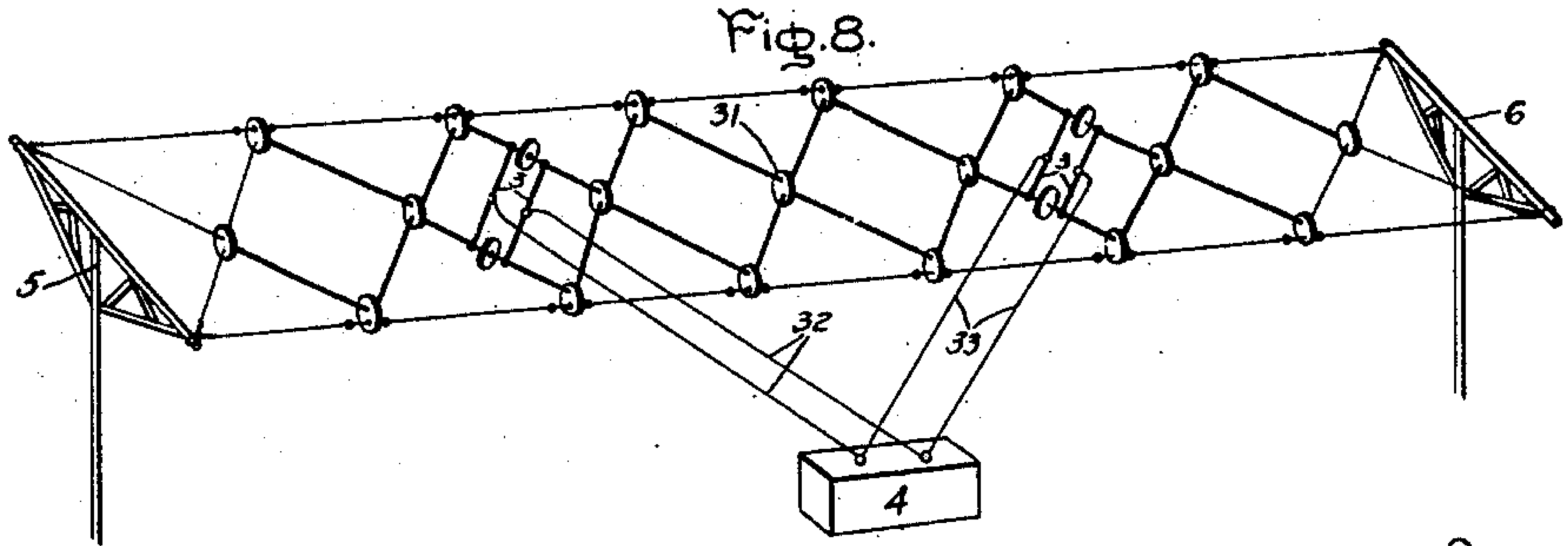

Fig. 9.

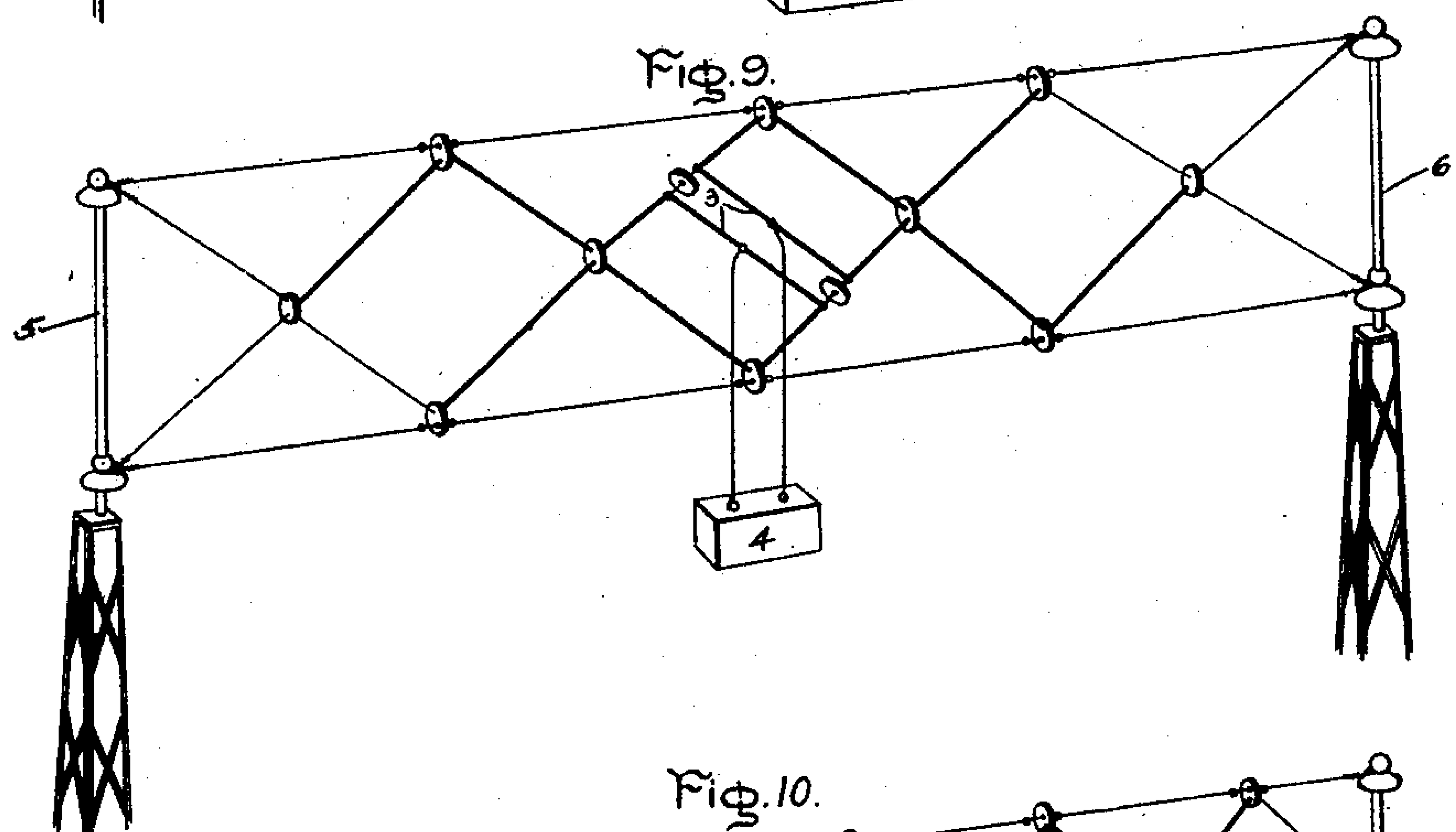

Fig. 10.

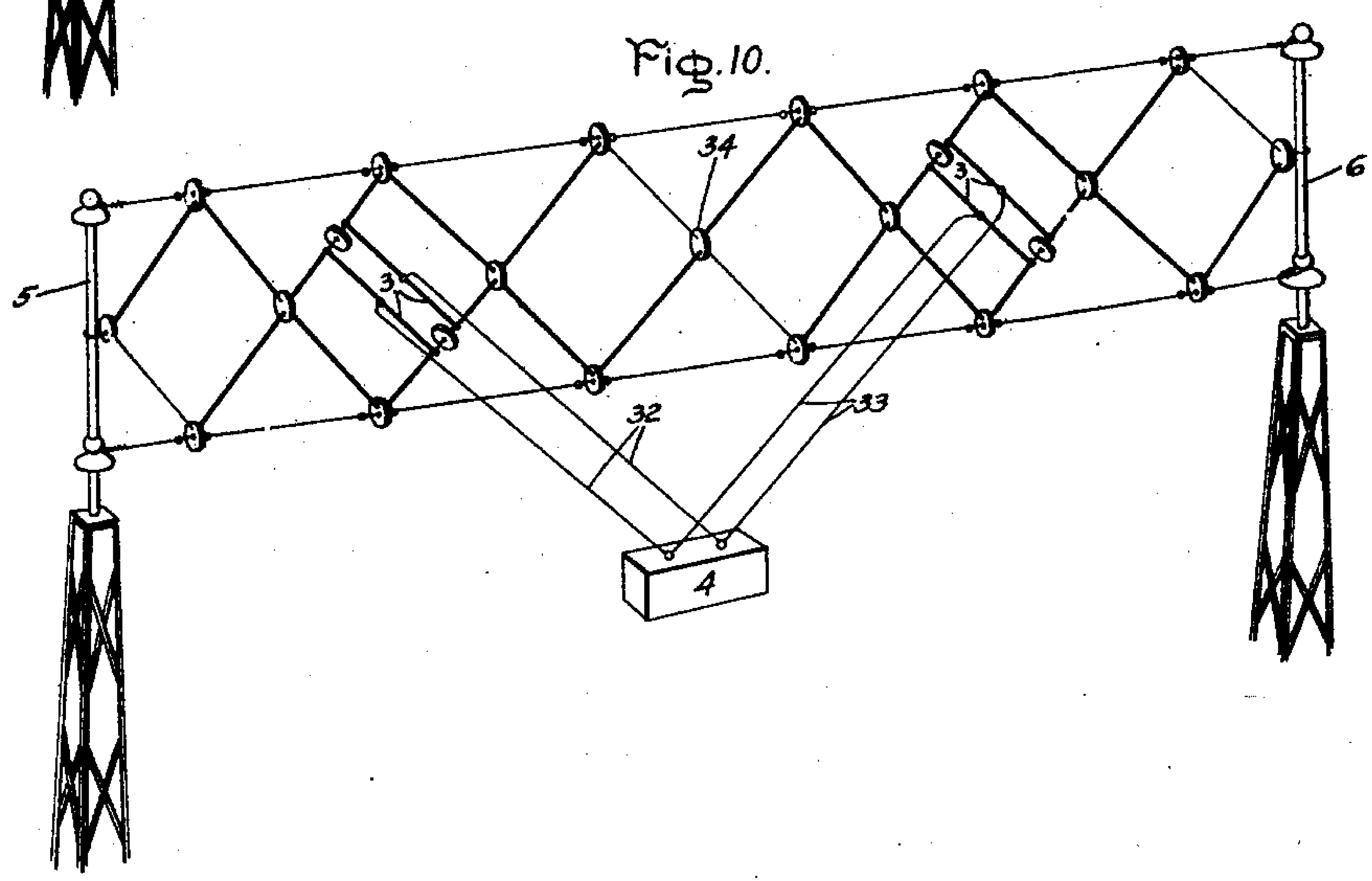

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Fig. 11.

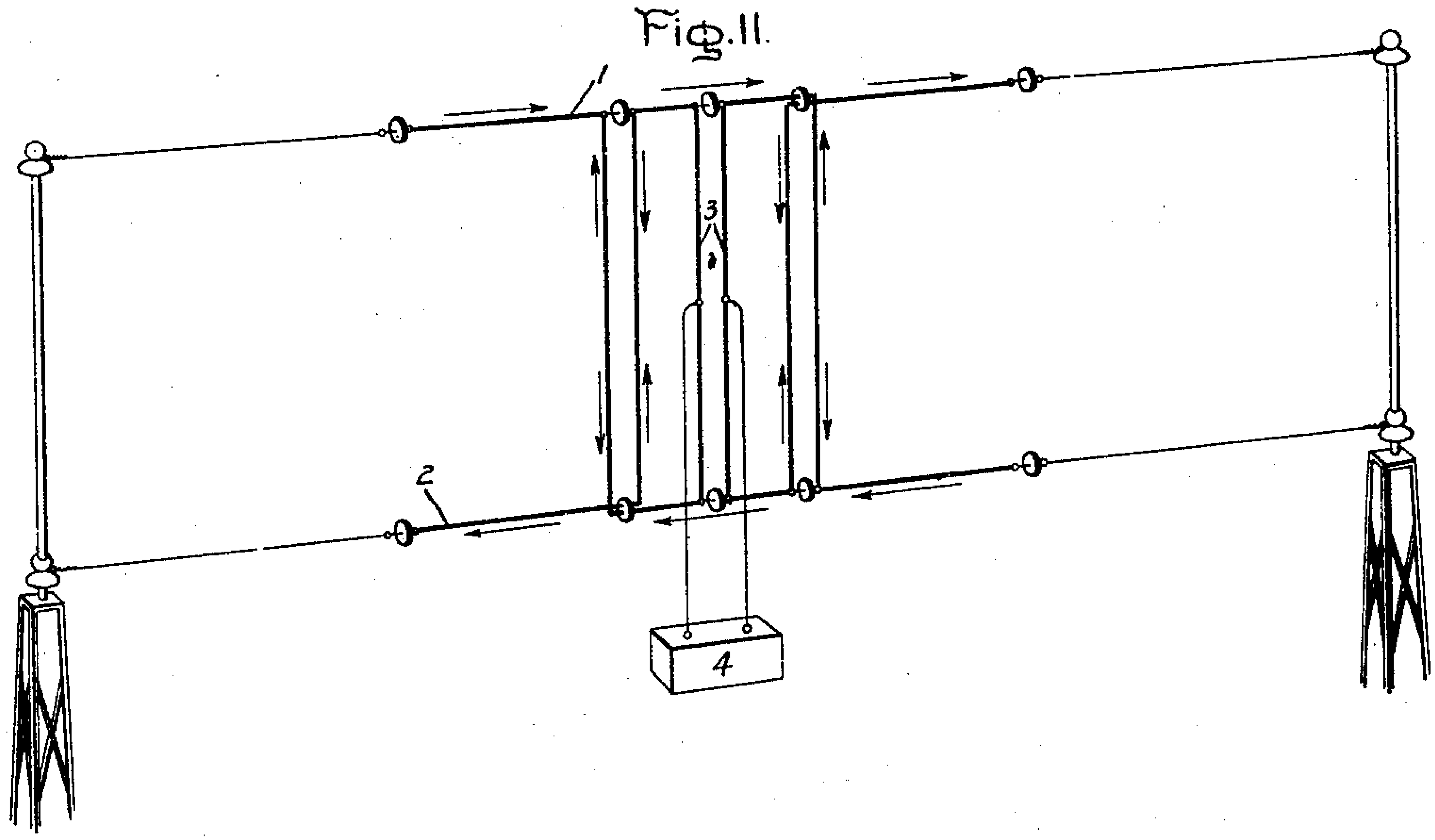
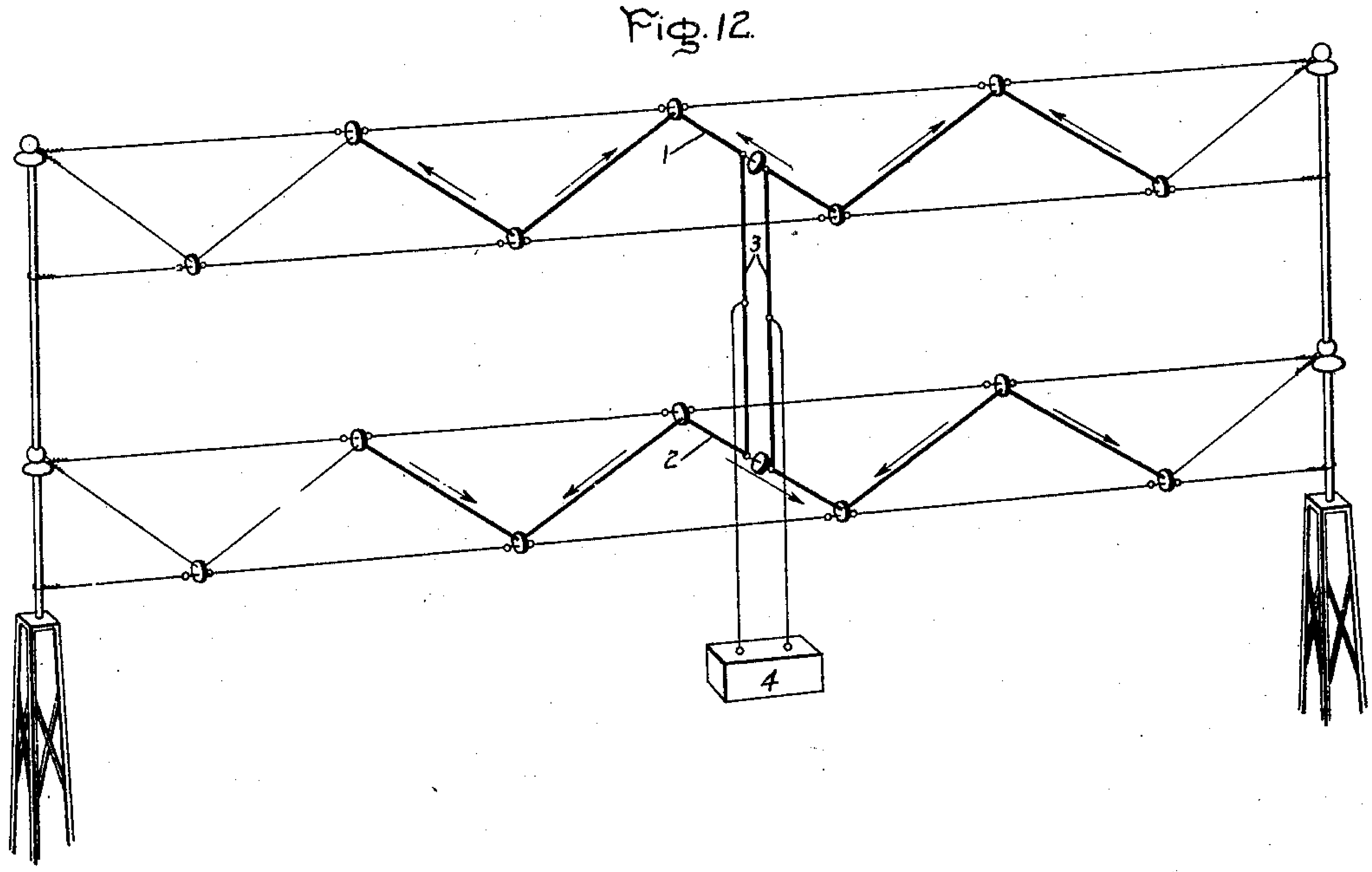


Fig. 12.



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Patented Sept. 16, 1930

1,775,801

UNITED STATES PATENT OFFICE

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RADIO SIGNALING SYSTEM

Application filed November 15, 1927. Serial No. 233,509.

My invention relates to radio signaling systems and more particularly to radio signaling systems which are adapted for operation on short waves. It has for its purpose to provide directive antenna systems for use in such systems which are easy to construct and maintain and which combine high radiating capacity and sharp directive properties with economy in construction and maintenance. A still further purpose of my invention is to provide an antenna system which may be constructed without the use of artificial inductance or capacity or tuning of any nature and which is therefore peculiarly capable of operation simultaneously on a number of different wave lengths. This latter characteristic of antennæ embodying my invention is of particular importance in connection with the problem of fading as well as in eliminating distortion resulting from fading.

Various theories have been advanced in the past to account for the erratic reception of radio waves and for the phenomenon known as fading. Among these is the theory of the Heavyside-Kennelly layer which theoretically comprises a conducting medium upon which waves travel to a remote point and from which waves are reflected and refracted to the vicinity of the receiver. Experiments with radio transmission appear to indicate that this layer is not a smooth surface but instead one which is not unlike that of the surface of the sea in various states of agitation. If a radio beam is radiated to this surface it may be reflected back to the earth in the vicinity of the receiver or to other vicinities dependent upon the condition of the layer. Consequently conditions of alternate reception and non-reception, or fading, occur at the receiver.

Accordingly one of the purposes of my invention is to provide an antenna which in addition to possessing sharp directive properties and the capacity to radiate large quantities of energy is also capable of operation at a plurality of wave lengths. Since the waves of different wave lengths may be affected differently by the fading phenomena of the ether or by different conditions of the Heavyside layer reception on one wave length or another may generally be had. Thus by employing either at the transmitter or at the receiver, or both, an antenna particularly adapted for this operation at a plurality of wave lengths more continuous reception may be expected. Such an antenna may more properly be termed a wave projector as contrasted with the usual beam antenna of the prior art which operates only on a single wave.

More particularly my wave projecting antenna comprises a plurality of half wave length sections all of which operate in unison and in phase to project either a single wave or a plurality of waves in a given direction. These sections my be arranged in a plurality of lines and in adjacent space relation in each line, thereby securing large radiating capacity and high directive properties of the antenna as a whole. The different half wave length sections of each line may be interconnected and arranged in a manner to be described such that all of the sections operate in phase and this without the use of condensers, inductance or tuning means of any kind which interfere with operation at a plurality of frequencies.

The novel features which I believe to be characteristic of my invention will be set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation may best be understood by reference to the following description taken in connection with the accompanying drawing in which Figs. 1 to 12 illustrate diagrammatically as many different embodiments of my invention.

In the drawings the heavy lines have been employed to indicate the conducting members of the antenna, whereas the light lines are used to indicate supporting cables which are employed in supporting the antenna from the appropriate towers. The necessary insulating members are represented by circular disks for convenience in illustration.

Fig. 1 of the drawing represents a simple form of antenna which embodies my invention. It comprises two conducting members

1 and 2, each of these members comprising a plurality of series connected alternately arranged sections. These sections in the case shown are arranged in a zig zag formation and extend alternately in the horizontal and vertical planes. Thus, for example, the conducting member 2 is composed of a set of horizontal sections *a*, *b*, and *c*, which are alternately arranged along the length of the antenna, and a set of sections *d*, *e* intermediate said alternate sections, which are in a vertical plane. Conductor 1, which is similarly formed of sections *a′*, *b′*, *c′*, *d′*, *e′*, is juxtaposed upon the conductor 1 in a manner such that two parallel continuous lines are formed and the pairs of sections *d*, *d′* and *e*, *e′* form opposite sides of a parallelogram between these lines. The upper of these lines comprises sections *a*, *b′* and *c* and the lower line comprises the sections *a′*, *b* and *c′*, these sections being arranged in adjacent space relation in each line, and each constituting a half wave length oscillating unit. The sections *b* and *b′* are interrupted at the midpoint thereof and the two conductors are connected together at this point by means of feed lines 3, at the midpoint of which are connected additional feed lines extending to the high frequency apparatus 4, which may comprise a transmitter or receiver. The feed lines 3 extending between the two lines may have a length equal to a half wave length or an integral multiple thereof as desired. The arrangement of the feed lines is such that the high frequency apparatus 4 is electrically equidistant from the midpoint of both of the conducting members 1 and 2. The conducting members 1 and 2 are suitably supported from appropriate towers 5 and 6 by means of cables 7 and are appropriately insulated from each other by means of suitable insulators 9, which in each of the drawings are represented as circular disks. The high frequency apparatus 4 may be operable to supply to, or to receive from, the antenna currents of one or more frequencies. If currents of a single frequency be employed, then the length of each of the sections of the antenna will be equal to one-half of a wave length corresponding to the frequency used, whereas, if more than one frequency is used, these sections will have a length equal to one-half of the average wave length of the waves employed. As thus arranged it will be seen that all the sections which comprise the parallel lines *a*, *b′*. *c* and *a′*, *b*, *c′* will be energized in phase, whereas the currents in the coextensive members *d*, *d′* and *e*, *e′*, which form oppositely disposed connecting links between the parallel lines, will flow in opposite directions as is indicated by the arrows with the result that the effect of these members will be neutralized. It will thus be seen that all of the horizontal members of the antenna will be energized in phase, and thereby cooperate to project, or to respond to, horizontally polarized waves propagated in a direction at right angles to the plane of the antenna, whereas the vertical members because of their opposed phase relations will have substantially no effect.

In Fig. 2 I have shown a further development of my invention which comprises two groups 10 and 11 of conductors arranged in the manner set forth in connection with Fig. 1. These groups are arranged to form two parallel lines in a vertical plane extending between the towers 5 and 6, each of these lines comprising six half wave length oscillating sections, all of which may be energized in phase by means of a transmitting equipment 4, which is connected through lines of equal length to the midpoint of the feeder conductor 3 of the two groups of conductors. This antenna will project a wave of a similar nature to that projected by the antenna shown in Fig. 1, but due to its greater length will have sharper directive and greater radiating properties than that of the former figure.

The directivity and radiating properties of the antenna will be still further increased by an arrangement of conductors such as that shown in Fig. 3. In this figure four groups of members 12, 13, 14 and 15, each of them being constructed in a manner illustrated in connection with Fig. 1, are suspended between towers 5 and 6. The groups 12, 13 and 14, 15 are suspended in vertical planes between spreaders 16 and 17 which are attached to the supporting mast 5 and 6, the length of these spreaders and consequently the distance between the two vertical planes comprising the groups 12, 13 and 14, 15 being equal to one-half of a wave length. In this case only the groups 14 and 15 are represented as being energized by means of the transmitter 4, the groups 12 and 13 serving as reflectors of the radiated waves.

Fig. 4 represents an antenna of the type shown in Fig. 1 but which is suspended between towers 5 and 6 in a manner such that the direction of propagation of the radiated waves may be varied as desired. The parallel lines of the antenna which are comprised of the alternate sections of the conducting members 1 and 2 are suspended between spreaders 18 and 19, which spreaders are suitably attached to the supports 5 and 6. These spreaders 18 and 19 are suspended in a manner such that they may be rotated in a vertical plane extending crosswise of the antenna. Opposite ends of the spreaders 18 and 19 are attached by means of ropes 20 and 21 respectively to stakes 22 which may be set in the ground at suitable distances from the base of the supports 5 and 6. By means of these ropes the angle of propagation of the radiated waves over the horizon may be adjusted. Thus, for example, by making the ropes 20 and 21 of equal length and by setting the stakes 22 in the ground at equal distances from the base of the support 5 the antenna will be suspended in the horizontal plane, thereby projecting horizontally polarized waves vertically upward. If the ropes 21 be lengthened and the ropes 20 shortened and the stakes 22 suitably adjusted, the antenna may be suspended in a vertical plane whereby horizontally polarized waves may be projected parallel to the surface of the earth. Suitable intermediate angles as desired between the direction of propagation of the radiated waves and the surface of the earth may accordingly be obtained.

Fig. 5 shows an antenna of the type represented in Fig. 2 similarly suspended so as to make the direction of propagation of the radiated waves over the horizon adjustable. Suitable means of the nature set out in Figs. 4 and 5 may also be employed in connection with an antenna having a group arrangement such as that shown in Fig. 3.

Fig. 6 represents a different manner of supporting an antenna of the type shown in either Fig. 2 or Fig. 5. In this figure two groups of conductors are suspended from the top of a tower 23 in end to end relation obliquely toward the ground, the lower ends of each of the lines of the radiating conductors being supported by means of suitable stakes 24 which may be set in the earth. As thus constructed this antenna will radiate a wave having a direction of propagation at right angles to the plane of the antenna and the plane of polarization determined by the angle between the plane of the antenna and the surface of the earth. The direction of propagation of this antenna may likewise be varied over the horizon by moving the stakes 24 to or from the base of the support 23. Thus, for example, the angle between the direction of propagation and the surface of the earth may be diminished as desired by so adjusting the stakes 24 that the plane of the antenna will fall into a plane determined by the dotted lines 25 or it may be increased by adjusting the stakes in the opposite direction.

Fig. 7 represents a further embodiment of my invention in which the two conducting members 1 and 2 are comprised of series connected alternately arranged sections which may be arranged in a general zig zag or staircase formation, the alternating sections of each conductor extending in opposite direction from the intermediate sections thereof. Thus, for example, the conductor 1 comprises sections *g*, *h*, *i*, *j* and *k*, the set of sections *g*, *i* and *k* being arranged in the horizontal plane and the intermediate set of sections *h* and *j* being arranged in the vertical plane. The conductor 2 is similarly formed of sections *g'*, *h'*, *i'*, *j'* and *k'* and is juxtaposed with reference to the conductor *l* in a manner such that the sections *h* and *h'*, and *j* and *j'* comprise continuous parallel lines and the sections *i* and *k'* and *g* and *i'* likewise form continuous parallel lines, all of the lines being in a common vertical plane but the latter lines extending at right angles to the former. It will be noted that all of the sections are in adjacent space relation in each line. The mid-sections of each of the conductors are connected by means of the feeders 3 in a manner already set forth in connection with Figs. 1 and 2 and the midpoints of these feeders are similarly connected to the high frequency apparatus 4. This antenna is adapted to be supported by means of a suspension member 26 which extends from the top of the tower 27 obliquely toward the earth. This form of antenna is of a type disclosed and claimed in a copending application of Samuel Nixdorf, filed Nov. 15, 1927, Serial No. 233,491, and which is assigned to the same assignee as my present application. It has certain advantages in its physical construction as well as in its method of operation which are fully set forth in the copending application.

When supplied with high frequency currents having a wave length equal to twice the length of the equal sections of the conductor, currents will flow in each of the conductors in a direction indicated by the arrows. It will thus be seen that all of the sections which are arranged in parallel relation are energized in phase and that this is true with both the horizontal and the vertical sections. Thus in this antenna both the vertical and the horizontal members produce radiation and the combined effect of the horizontal and vertical members is to project a wave in a direction at right angles to the plane of the antenna having a plane of polarization at 45 degrees upward, as is indicated by the arrow 28.

Fig. 8 represents a further embodiment of my invention in which two groups of conductors, such as that shown in Fig. 7, are suspended in end to end relation and in a horizontal plane between supports 5 and 6. These groups are insulated from each other at the point 31 and are energized by means of conductors 32 and 33 of equal length which extend from the midpoint of the feeder section 3 to the high frequency apparatus 4. As thus arranged this antenna will radiate a wave in a vertical direction which has a horizontal plane of polarization. Such an antenna will have particular utility in connection with the direction of aircraft.

Figs. 9 and 10 represent further developments of the form of my invention represented in Fig. 7. Fig. 9 represents a single group of conductors which are suspended in a vertical plane between the masts 5 and 6, each of the sections of each conducting member being disposed at 45 degrees to the horizontal. Fig.

10 shows two groups of conductors similarly arranged extending in end to end relation in a vertical plane between the supports 5 and 6. These groups of conductors are insulated from each other at the point 34 and are adapted to be supplied with high frequency currents through the conductors 32 and 33 which are of equal length and extend from the high frequency apparatus 4 to the midpoint of the feeder sections 3. These antennæ as represented by Figs 9 and 10 will transmit vertically polarized waves having a direction of propagation at right angles to the plane of the antenna.

Figs. 11 and 12 represent antennæ of the type shown in Figs. 1 and 9 respectively with the exception that the spacing between the upper and lower portions of the antennæ is greater. In each of these figures the length of the feeder conductors 3 is equal to a full wave length with the result that the currents in the lower portion are reversed in direction with respect to that shown in the other figures. These antenæ will project or respond to waves propagated at a right angle to the plane of the antenna but thirty degrees upward over the horizon. The angle may be reduced to fifteen degrees by increasing the distance to two wave lengths. In the form shown in Fig. 12 the distance between the upper and lower portions is arbitrary.

It will be seen that, by an arrangement of conductors such as that described, any desirable length of antenna may be had, all of the half wave length sections of each of the parallel lines of the antenna cooperating in phase and being arranged in adjacent space relation. The fact that the various sections are energized in phase greatly increases the signal strength which may be had at a remote point with a given energy input to the antenna. Tests with an antenna of the type shown in Fig. 1 have indicated that far less energy is required to produce a certain signal strength at a given point than would be required by the usual half wave length horizontal doublet. The directive properties of the antenna are likewise increased both in the horizontal and vertical planes. This characteristic of the antenna is enhanced by the fact that the individual oscillating units, or sections, are arranged in adjacent space relation in each line.

While in each of the figures shown the conductors comprising the antenna each include an odd number of sections it will be understood that an even number may be employed as well. Likewise while in each case the antenna is represented as being fed at a midpoint of a mid-section any suitable manner of feeding well-known in the art may be employed. While the conductors may be of any suitable length it is desirable that the length should not be so great that the difference between the energization of the more remote sections and the sections proximate to the feeder conductors becomes appreciable. The preferred arrangement where a long antenna is desired is that shown in Figs. 2, 3, 5, 6, 8 and 10 since with these arrangements all of the sections will be substantially equally energized. Likewise the angle between adjacent sections of any conductor while preferably about ninety degrees may be any substantial angle.

While I have shown and described certain embodiments of my invention it will of course be understood that I do not wish to be limited thereto since many further modifications of the arrangements shown and of the instrumentalities employed may be made without departing from the spirit and scope of my invention as set forth in the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In combination, an antenna comprising a conductor including a number of substantially equal series connected sections, certain of said sections being alternately arranged along the length of said conductor and in parallel relation and certain other of said sections being arranged intermediate said alternate sections and at an angle thereto, a second similar conductor arranged in proximity to said first conductor to form parallel lines including sections of both conductors, high frequency apparatus adapted for operation at a wave length equal to approximately twice the length of said substantially equal sections and connections from the mid-point of each of said conductors to said high frequency apparatus.

2. An antenna comprising a conductor including a number of substantially equal series connected sections, certain of said sections being alternately arranged along the length of said antenna and in horizontal parallel relation and certain other sections being arranged intermediate said alternate sections and at an angle thereto, and a second similar conductor arranged in such juxtaposition with said first conductor that said alternately arranged sections of both conductors form continuous parallel horizontal lines spaced apart by at least one half of a wave length of the wave on which said antenna operates and certain intermediate sections of both conductors are coextensive with each other.

3. In combination, an antenna comprising a plurality of pairs of conductors, each conductor of each pair comprising a plurality of substantially equal series connected sections, certain sections of which are alternately arranged along the length of said conductor and in parallel relation with certain sections of all of the conductors and other sections of which are arranged intermediate said alternately arranged sections

and at an angle thereto, said alternately arranged sections of all of the conductors forming parallel lines and said intermediate sections extending between said lines, high frequency apparatus and lines of equal electrical length extending from said high frequency apparatus to a point intermediate each of said pairs and from said point to each conductor of said pairs whereby parallel sections of all of said conductors produce cooperative effects.

4. An antenna adapted for operation on horizontally polarized waves comprising a plurality of sections, said sections being arranged in horizontal parallel rows spaced apart by a distance of one-half of a wave length, each row comprising a plurality of equal sections arranged in end to end relation, high frequency apparatus connected to the mid-point of the middle sections of each of said rows, and means for so coordinating all of said sections that they carry currents in phase when high frequency oscillations are impressed upon said antenna.

5. A system for radiating horizontally polarized waves comprising an antenna having a plurality of equal sections, said sections being arranged in horizontal rows in a substantially vertical plane and spaced apart in said plane by a distance of one-half of a wave length of the wave on which said antenna operates, means for supplying high frequency oscillations to said antenna having a wave length equal to twice the length of said equal sections, means for so coordinating all of said sections that they carry currents in phase, and a second antenna comprising sections similarly arranged in a vertical plane on the side of said first vertical plane opposite the direction in which waves are to be propagated, energy being supplied to said second antenna entirely through the inherent coupling between said antennæ.

6. An antenna adapted for operation on horizontally polarized waves, comprising a plurality of equal sections arranged in horizontal rows spaced apart by one-half of a wave length of the wave on which said antenna operates, said rows being arranged in a substantially vertical plane, and each of said rows including at least three of said equal sections, high frequency apparatus connected to the mid-point of the middle section of each row, and means for so coordinating all of said sections that they carry currents in phase when high frequency oscillations are impressed on said antenna.

In witness whereof, I have hereunto set my hand this 14th day of November, 1927.

ERNST F. W. ALEXANDERSON.