

Dec. 9, 1958

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2,863,531

TOWER ERECTING APPARATUS

Filed Nov. 19, 1956

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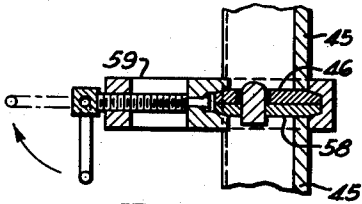


Fig. 8

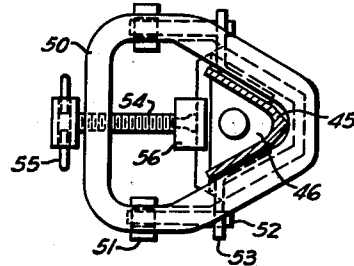


Fig. 6

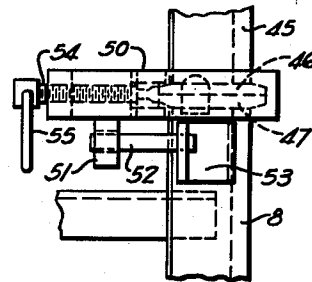


Fig. 7

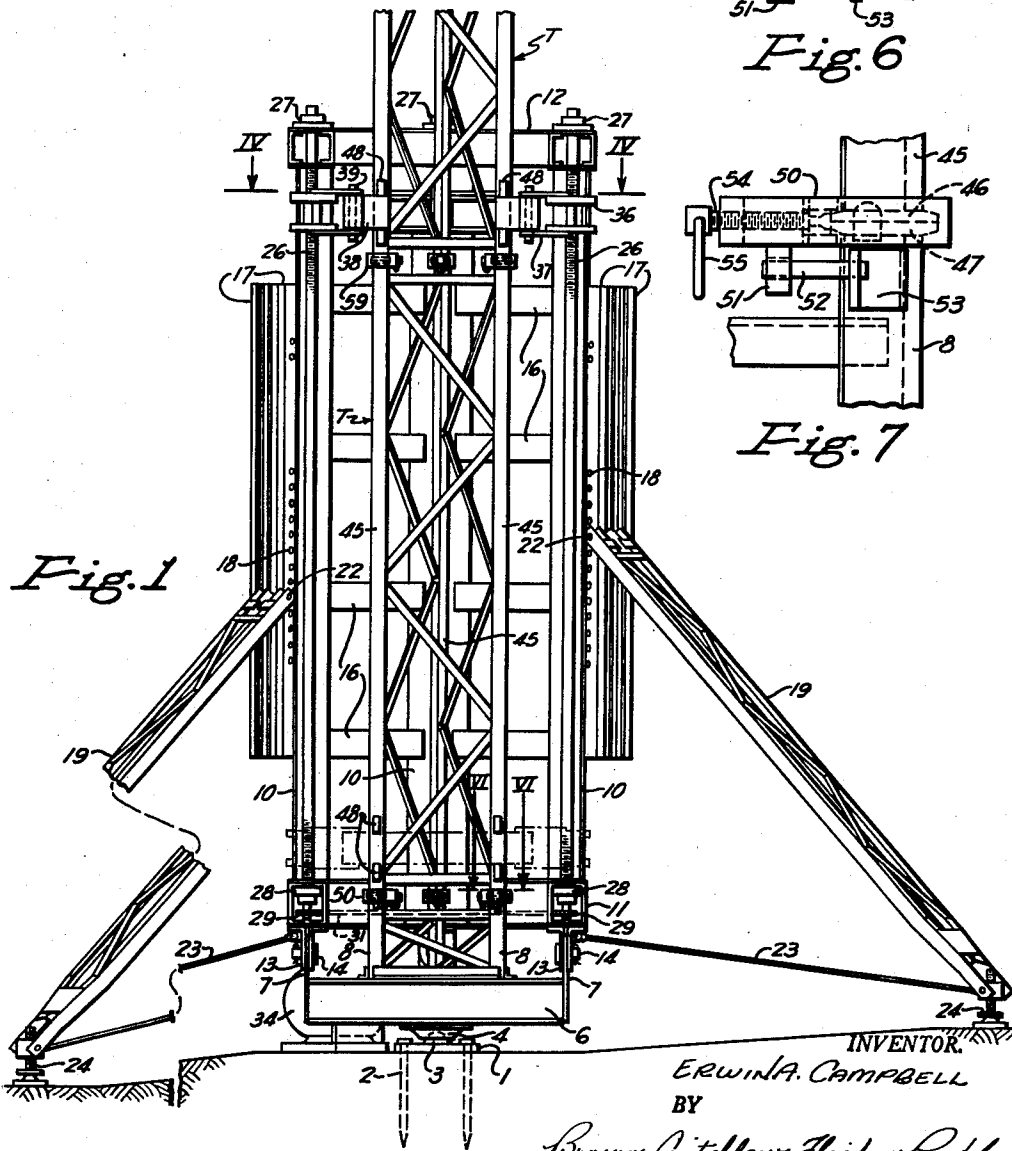


Fig. 1

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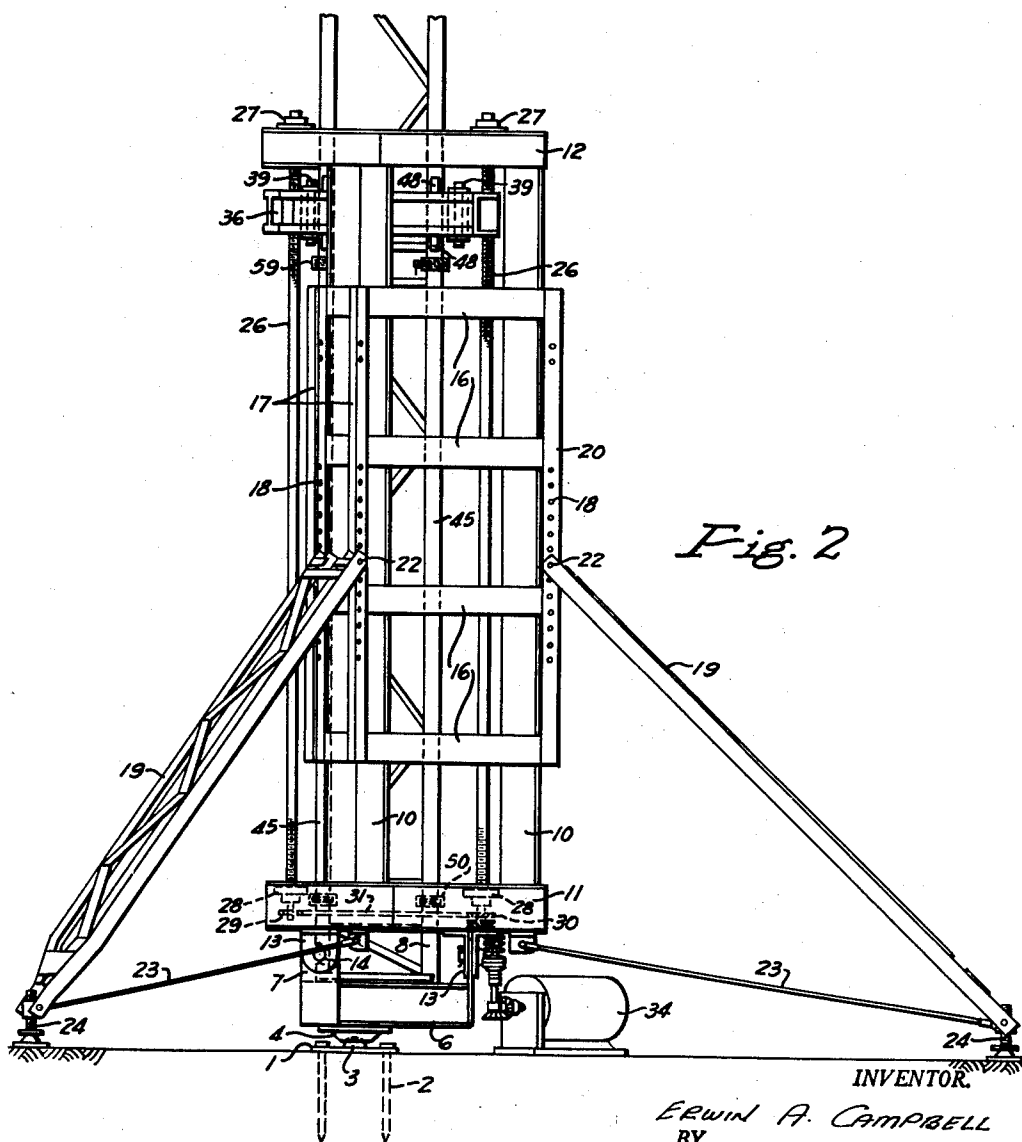


Fig. 2

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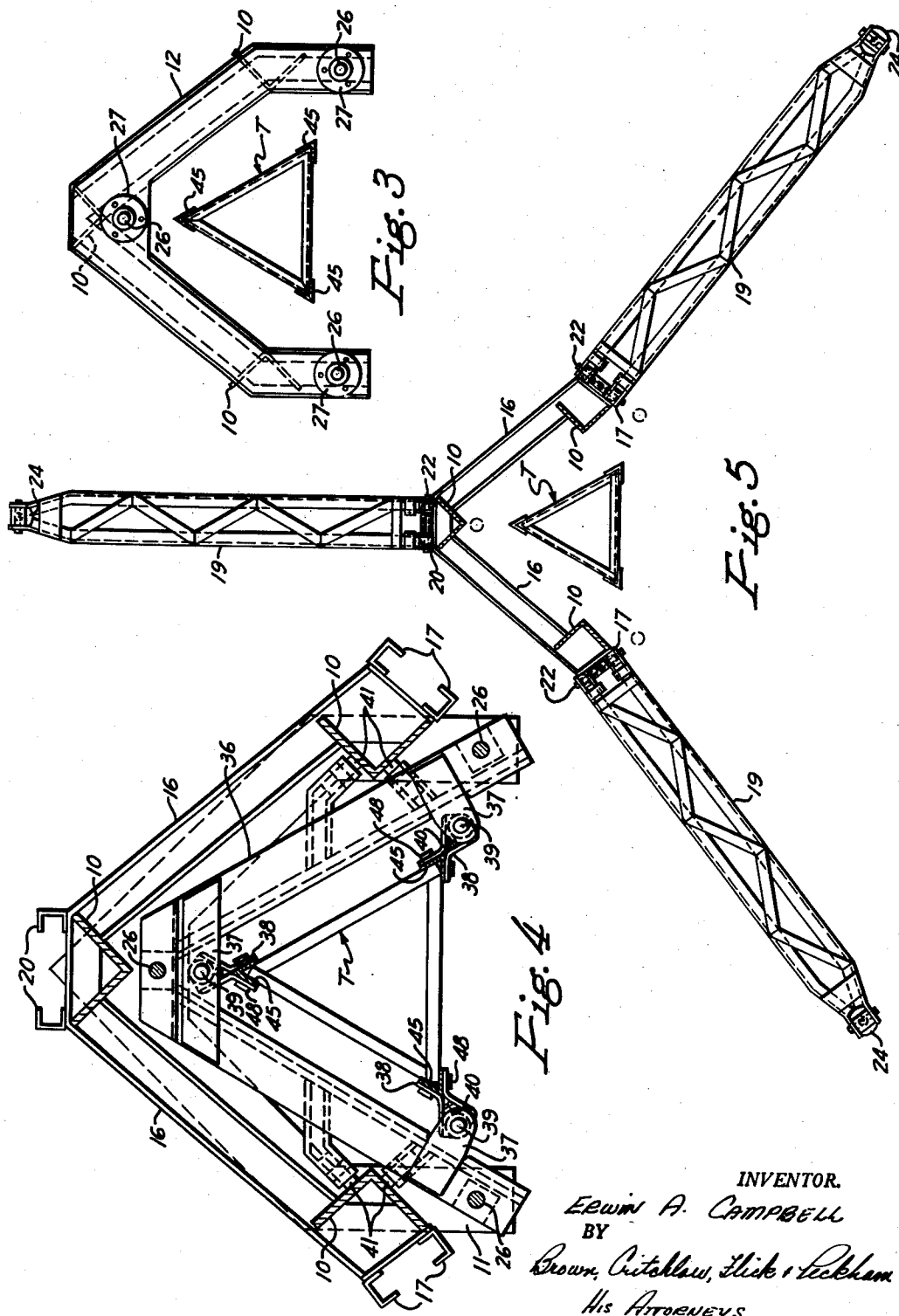
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5 Sheets-Sheet 3



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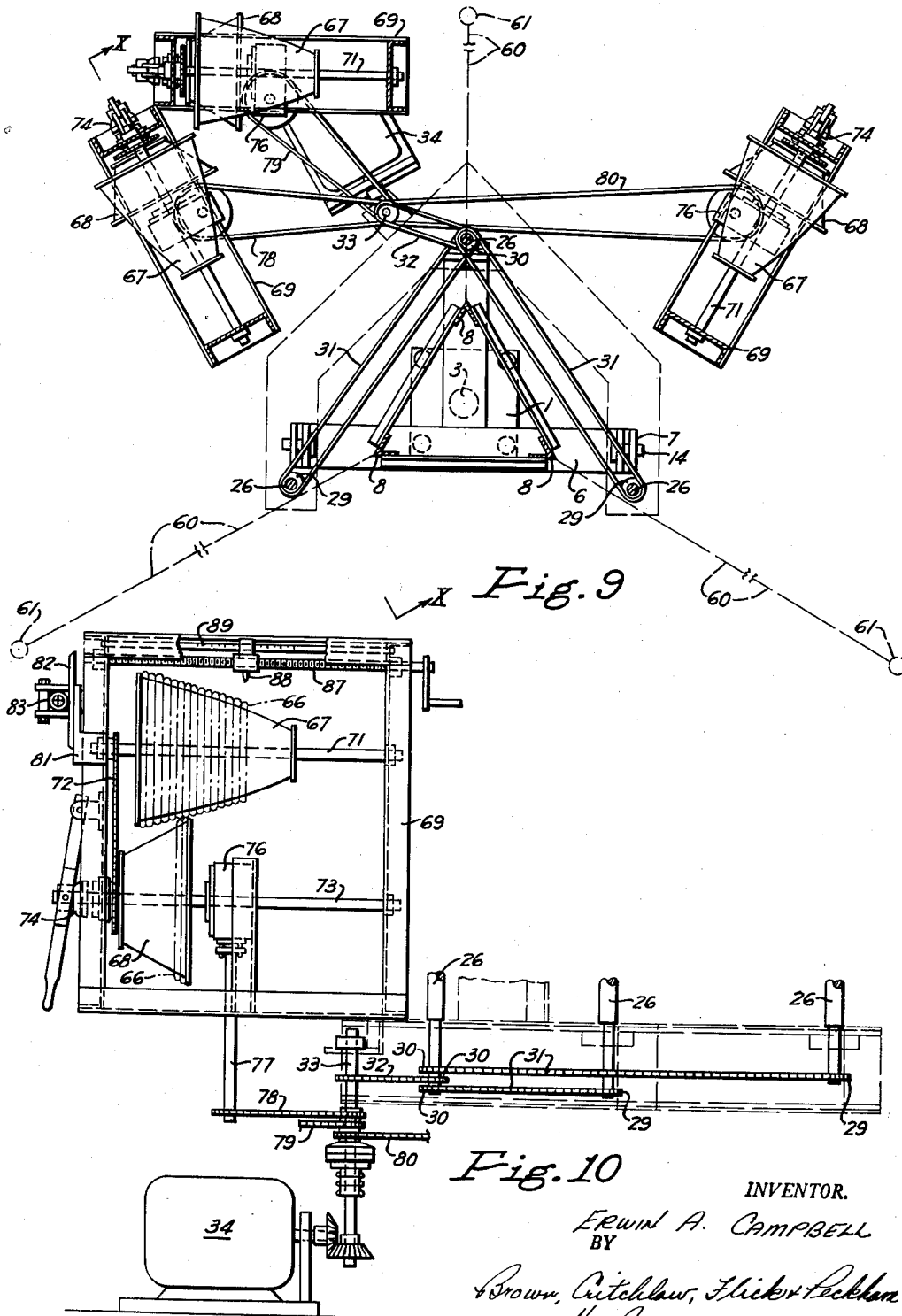
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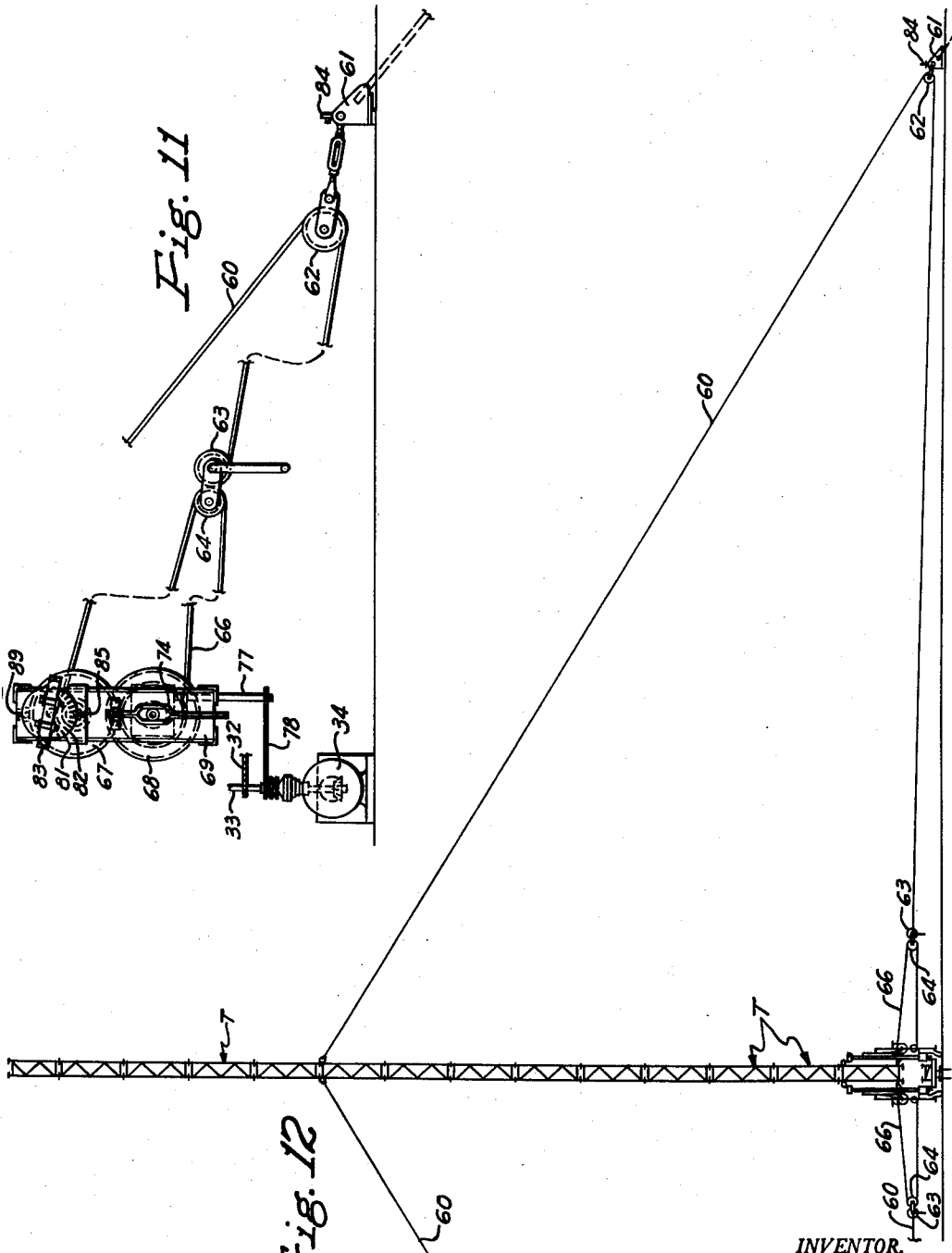


Fig. 12

Fig. 11

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TOWER ERECTING APPARATUS

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12 Claims. (Cl. 189—12)

This invention relates to apparatus for erecting towers from prefabricated sections by pushing them straight up, and more particularly to apparatus which simultaneously raises a tower axially and feeds out the tower guy lines under tension.

There are occasions when it is highly desirable to be able to erect a tall tower quickly and to take it down equally rapidly for transportation to another location. This is especially true of communications towers, such as radio and radar towers for military use, which may be useful in a given location for only a short time. To erect the towers piece by piece, by bolting the numerous elements together, would require an unreasonably long time and involve working at very high elevations. There also is the problem of stringing guy lines as the tower is erected so that it will be suitably braced. With such tall towers, it is not feasible to assemble them along the ground and then attempt to swing them up to upright position.

It is among the objects of this invention to provide tower erection apparatus which can rapidly erect a tower from prefabricated vertical sections, which also can be used for taking the tower down, which can easily be removed from the tower as soon as erection is completed, which is simple in construction and operation, and which automatically takes care of the guy lines and holds them taut as the tower is raised or lowered.

In accordance with this invention an upright frame, having an open side for receiving an upright tower section, is removably mounted on a base member. Means are also supported by the base member for detachably connecting the bottom of the tower section thereto. A plurality of vertical jack screws are rotatably mounted in the frame and have lifting means threaded on them for vertical travel when they are rotated. Means are provided for supporting the tower section from the lifting means after the section has been disconnected from the base member, whereby the tower section can be raised to make room for another similar section inserted below it. Guy lines are connected to the tower above the frame, and means are operatively connected with the lines for paying them out under tension at a predetermined rate as the tower is raised by the lifting means. The lines are thereby kept taut as the tower is raised, in order to support it in vertical position.

The preferred embodiment of the invention is illustrated in the accompanying drawings, in which

Fig. 1 is a front view of my tower receiving and elevating apparatus;

Fig. 2 is a side view thereof as seen from the right-hand side of Fig. 1;

Fig. 3 is a top view;

Fig. 4 is an enlarged horizontal section taken on the line IV—IV of Fig. 1;

Fig. 5 is a horizontal section showing the outriggers from above;

Fig. 6 is an enlarged horizontal section, taken on the line VI—VI of Fig. 1, of one of the foot clamps;

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Fig. 7 is a side view of the same clamp;

Fig. 8 is an enlarged vertical section through one of the upper leg clamps;

Fig. 9 is a plan view of the jack screw rotating mechanism and the guy line controllers;

Fig. 10 is an enlarged side view of one of the guy line controllers taken on the line X—X of Fig. 9;

Fig. 11 is an end view of the same guy line controller showing it connected with a guy line; and

Fig. 12 is a diagrammatic side view of a tower being raised.

Referring to Figs. 1 and 2 of the drawings, a foundation member 1, which may consist of a heavy metal plate, is anchored in a desired position on level ground by driving long headed stakes 2 down through its corners. Secured to the center of the plate is the upper half of a ball 3, on which a spherical socket 4 is seated to form a ball and socket joint. The socket is mounted on the bottom of a base member 6, which may be formed from two metal I-beams secured together in the shape of a T (Fig. 9). The cross arm of the T forms the front of the base member. Upwardly extending plates 7 are mounted on its opposite ends and on the outer end of the stem of the T. Rigidly mounted on the base member are short posts 8 corresponding in number, position and cross sectional shape with the legs of the tower that is to be erected and that is to rest on those posts. Although the tower may have four legs if desired, three generally are sufficient. In such a case, two of the posts are mounted on the cross arm of the base and the third post is mounted behind them on the stem. The posts are suitably braced.

Removably mounted on the base member 6 is a tower-receiving frame, which is formed from tall columns 10 rigidly mounted at their lower ends on a bottom yoke 11 and rigidly connected at their upper ends by a top yoke 12. The yokes have open fronts, and for a three-legged tower only three columns are used. The bottom yoke is provided with depending brackets 13 that straddle the upright plates 7 on the base member and are connected to them by removable coupling pins 14. Between the yokes, the frame is reinforced by horizontal braces 16 secured to the columns and projecting straight past the front columns as shown in Fig. 4. To the front end of each of these braces are secured a pair of laterally spaced vertical channels 17, which face each other. The webs of the channels are provided with vertically spaced holes 18 for vertical adjustment of the upper ends of downwardly inclined outriggers 19. Similar channels 20 are secured to the back of the rear column for the same purpose.

The upper end of each outrigger is slotted so that it can straddle the adjoining channels, and is provided with holes that can be aligned with any of the holes in the channels. A pivot pin 22 extends through the outrigger holes and the two channels for pivotally connecting the outrigger thereto. The pin can be removed so that the outrigger can be raised or lowered to another position according to the topography. The outer end of the outrigger is connected to the bottom yoke of the frame by a cable 23. When the frame is set on the base member and temporarily held perfectly vertical, the upper ends of the outriggers are disconnected from the frame and their lower ends are moved out as far as the restraining cables will allow. Then the upper ends are pinned to the frame at whatever level they happen to be. By adjusting jacks 24 pivotally mounted on the outer ends of the outriggers, the frame can be held vertical by the outriggers.

The frame also includes three vertical jack screws 26, one for each leg of the tower. The upper ends of these screws are suspended from bearings 27 mounted on the

top yoke, and the lower ends of the screws are rotatably and slidably mounted in bearings 28 inside of the bottom yoke. Consequently, while the screws are supporting a load, they will be under tension and there will be no danger of their buckling. The screws are rotated in unison by sprockets keyed on their lower ends. There is one sprocket 29 on each front screw and three sprockets 30 (Fig. 10) on the rear screw. The front sprockets are connected to two of the rear sprockets by chains 31. The third sprocket on the rear screw is driven by a chain and sprocket drive 32 from a vertical drive shaft 33 connected to the side of the bottom yoke of the frame. The lower end of this shaft is driven by any suitable source of power, such as an electric motor 34. It will be seen that the motor will drive all three jack screws simultaneously.

Threaded on the three jack screws within the frame is a lifting member or cradle 36 formed, as shown in Fig. 4 from two side members joined at their rear ends and diverging forward so that their front ends are spaced apart to provide the cradle with an open front. When the screws are turned, the cradle will be moved up or down in the frame. The cradle is provided at its back and front with inwardly projecting brackets 37, in each of which a pair of short arms 38 are pivotally mounted on a vertical shaft 39. The inner or free ends of the arms are bent in such a manner that they will lie flat against opposite sides of a tower leg, where they can be held by a vertical pin 40 inserted in holes in overlapping lugs projecting from the inside of the arms. The cradle is stabilized laterally by guide members 41 projecting from it into engagement with front columns 10, as shown in Fig. 4.

To use the apparatus described thus far, after it has been set up in the desired location, a prefabricated tower section T is moved into the open front of the frame and set on the upper ends of the posts. The lower ends of the legs 45 of the tower section are provided with feet 46 in the form of triangular plates, as shown in Figs. 6 and 7. These plates rest on like plates 47 joined to the tops of the posts. As soon as the first or top section of the tower has been set on the posts, the cradle arms 38 are swung in against the sides of the tower legs and fastened there by the retaining pins 40. Directly above and below each arm there is a block 48 welded to the adjoining tower leg. The arms lift against the upper blocks. The jack screws then are operated to raise the cradle, which in turn will lift the tower section upward in the frame to a position slightly higher than the upper tower section shown in Fig. 1. Before the cradle strikes the top yoke of the frame, the screws are stopped and a new section of the tower is inserted in the frame beneath the raised section. This new section and all subsequent sections should be fastened to the base member to anchor the bottom of the tower while the cradle is being lowered. This can be done quickly and easily by mounting a leg clamp on the upper end of each post.

Each leg clamp includes a horizontal ring 50 surrounding a post plate 47 and provided with depending bosses 51 having parallel horizontal openings therethrough. These bosses are slidably mounted on pins 52 projecting from brackets 53 secured to the opposite sides of the post so that the ring can be moved back and forth across the post. The portion of the ring that extends along the opposite sides of the post is tapered to the same extent as plates 46 and 47 and is provided with a clamping groove capable of receiving the edges of those plates. Threaded in the wide side of the ring is a screw 54 that has a handle 55 on its outer end. The inner end of the screw is rotatably mounted in a slotted block 56 that will fit over the adjoining plates. After a tower section has been set on the posts, the screws 54 are turned to cause the rings to be moved toward the outer ends of the screws and thereby to draw the ring grooves over

the inclined edges of the triangular plates. This clamps the plates together.

The upper ends of the new tower section legs are provided with plates 58 (Fig. 8) corresponding in shape and size to the feet of the raised section. Before the raised section is lowered by the cradle onto the new section, clamping rings 59 are dropped over the upper ends of the lower section legs. The raised section then is lowered onto the new section, and the clamping rings are raised into position around the adjoining plates 46 and 58. These rings are similar to the clamping rings 50 and are tightened in place in the same way. These upper clamps therefore rigidly connect the two sections together. When that operation has been completed, the cradle arms 38 are swung away from the tower and the screws are reversed to lower the cradle to the bottom of the frame where it can be attached to the new section of the tower. The post clamps then are released and the new section is raised by the cradle, whereby the previously raised section will be elevated still farther and will completely leave the top of the frame.

This operation of first inserting a tower section and then raising it so that a new section can be inserted below it is repeated until a tower of the desired height has been erected. During erection, guy lines steady the tower and help to keep it from falling over as will be described presently. After erection has been completed, the frame can be disconnected from the base member by removing pins 14 and pulled away from the back of the tower so that the bottom of the tower will be unobstructed. The tower then will be supported only by the base member and the guy lines.

As the tower is raised in this manner, it must be guyed, but, of course, the guy lines must be lengthened as the tower rises. Heretofore, this has presented a serious problem, but in accordance with this invention it is solved by providing means for automatically lengthening the guy lines as the tower rises, while keeping them under tension. For this purpose, each guy line 60 extends from a leg of the tower above the frame, out to an anchor point spaced the proper distance from the base of the tower, as indicated in Figs. 9, 11 and 12. At the anchor points earth anchors 61 are provided, each of which supports a vertical sheave 62. The guy lines extend down around the sheaves and then straight back toward the tower erection apparatus. The lower end of each guy line is secured to a small hand operated take-up reel 63 that carries at one side a sheave 64. This sheave is mounted in the loop of a cable 66, the opposite ends of which are secured to a pair of vertically spaced tapered drums 67 and 68 in an upright frame 69. This frame may be held securely in position in any suitable manner (not shown). The upper drum 67 is keyed on a shaft 71 journaled in the frame and driven from the lower drum by a chain and sprocket drive 72 (Fig. 10). The lower drum is journaled on a rotary shaft 73, by which it is driven when a lever-operated clutch 74 is engaged. The lower shaft is driven through a gear box 76 by a vertical shaft 77, the lower end of which is connected by a chain and sprocket drive 78 to the main drive shaft 33. This drive shaft also drives the other two pairs of drums in the same way, through chains 79 and 80, so that all three sets of drums operate in unison and are synchronized with the rotation of the jack screws. The drums are tapered so that as cable 66 is wound onto the take-up drum from the pay-out drum 67, the length of the loop will change. The ends of the cable are fastened to the large ends of the drums.

Assuming that an anchor sheave 62 is at substantially the same level as the point of attachment of the upper end of the associated guy line 60 with the tower, the distance between that upper end and the anchor sheave will increase continuously and at an increasing rate as the tower rises. Before starting to raise the section of the tower attached to the guy line, the clutch 74 is dis-

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engaged and some of cable 66 is pulled off the pay-out drum. This will rotate that drum and cause it to rotate the take-up drum, on which the cable will be wound. This procedure is continued until the point is reached at which the cable is being unwound from the pay-out drum just as fast as it is wound on the other drum. Then the clutch is engaged and, the guy line being connected to the outer end of the loop in cable 66, the two drums are rotated together by motor 34. As the cable then will leave an increasing diameter of the tapered pay-out drum and wind onto a decreasing diameter of the take-up drum, it will leave the first drum at a progressively faster rate while it is wound on the other drum at a progressively slower rate. This will cause the loop to lengthen at a steadily increasing rate, which will feed out the guy line through anchor sheave 62 as the tower rises and yet will keep the line taut at all times, due to the special design of the drums. Upon completion of erection, the guy line is clamped in any suitable manner at the anchor sheave so that the line can be released from the cable loop.

In case anchor sheave 62 is at a higher elevation than the upper end of the guy line when the line is first attached to the tower, the drums should not be started in operation until they have been turned by hand to remove most of the cable from the take-up drum and to fill or nearly fill the pay-out drum with cable. Then, when the clutch is engaged and the drums are rotated, the cable will be wound on the large end of the take-up drum faster than it leaves the small end of the pay-out drum and the cable loop will shorten and pull in the guy line. This will continue until the upper end of the guy line reaches the same elevation as the anchor sheave, by which time the cable will have reached the points on the two drums where it will start to leave the pay-out drum faster than it is wound on the take-up drum. This will reverse the motion of the cable loop and cause it to lengthen so that the guy line will be paid out as the tower rises farther as described in the example given in the preceding paragraph.

A third situation also is possible, which occurs when anchor sheave 62 initially is at a lower elevation than the upper end of the guy line. In such a case the guy line must be let out faster from the start than in the first example given above. The procedure therefore is to disengage the clutch and rotate the drums by hand until the cable is leaving the pay-out drum faster than it is being wound on the take-up drum. The precise ratio will depend on how low the anchor sheave is at the start. When the drums are then driven by the motor, the loop will immediately start lengthening at the desired rate, which will continue to increase as the mast is raised.

In order to simplify the original manual setting of the drums for any given situation, and to insure that they will be set accurately so that the guy line will be kept under the desired tension as the mast rises, mechanical calculating and adjusting means are provided. Thus, as shown in Figs. 10 and 11, a bracket 81 may be secured to one side of each drum frame 69 for pivotally supporting a disc 82, on which a graduated arc is marked. The central portion of a sighting tube 83 is clamped against the disc at its center. The tube can be tilted in a vertical plane containing the anchor sheave 62 that is associated with the particular drum frame that supports the tube. By sighting through the tube at the sheave, or preferably at a target 84 (Fig. 12) mounted on anchor 61 directly behind the sheave, the tube will be tilted to a certain angle and one of the divisions of the graduated arc will be located directly above or close to a pointer 85 (Fig. 11) marked on bracket 81.

The next step is to turn a horizontal screw 87 (Fig. 10), journaled in the top of the drum frame, to move along the screw a pointer 88 that has an upper portion which slides along a calibrated rod 89 rigidly mounted above the screw. The rod is indexed to the graduated arc on disc 82, so the pointer is moved until it is set at the figure on the rod that corresponds to the reading of the gradu-

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uated arc. The pay-out drum then is rotated by hand until the point of departure of cable 66 from it is below the pointer. The drums are then ready for the initial rate and direction of cable loop travel demanded by the position of anchor sheave 62 relative to the upper end of the guy line.

After the guy lines have been attached to the tower and tightened, it may be desirable to fold up the outriggers 19 to avoid any possibility of binding between the erecting frame and the guyed tower in case the frame is forced out of plumb by settling earth or other causes.

It will be understood that the tower may be so tall as to require guy lines at different levels. Such additional lines can be controlled by other tapered drums operated in the same general manner as those already described.

According to the provisions of the patent statutes, I have explained the principle of my invention and have illustrated and described what I now consider to represent its best embodiment. However, I desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

I claim:

1. Tower erection apparatus comprising a base member, an upright frame removably mounted on the base member and having an open side for receiving an upright tower section, means supported by the base member for detachably connecting the bottom of a tower section to the base member, a plurality of vertical jack screws rotatably mounted in the frame, means for rotating the screws, lifting means threaded on the screws for vertical travel when they are rotated, inclined outrigger legs beside the frame, means pivotally connecting the upper ends of said legs to the frame, said connecting means being connectable to the legs in a plurality of different vertically spaced positions, and means adapted to support the tower section from said lifting means after it has been disconnected from the base member, whereby the tower section can be raised to make room for a similar tower section below it in the frame.

2. Tower erection apparatus comprising a base member, an upright frame removably mounted on the base member and having an open side for receiving an upright tower section, a plurality of posts supported by the base member, a horizontal plate rigidly mounted on the upper end of each post, the plates being adapted to support feet on the bottom of a tower section, a horizontal clamping ring surrounding each plate, means slidably mounting said rings on the posts for horizontal movement, the inside of each ring being provided with a groove for receiving and clamping together the adjoining plate and foot when the ring is moved horizontally, manually operable means carried by each ring for effecting said horizontal clamping movement, a plurality of vertical jack screws rotatably mounted in the frame, means for rotating the screws, lifting means threaded on the screws for vertical travel when they are rotated, and means carried by the lifting means adapted to support the tower section therefrom after said clamping rings have released it from said posts, whereby the tower section can be raised to make room for a similar tower section below it in the frame.

3. Tower erection apparatus comprising a base member, an upright frame removably mounted on the base member and having an open side for receiving an upright tower section, means supported by the base member for detachably connecting the bottom of a tower section to the base member, a plurality of vertical jack screws rotatably mounted in the frame, means for rotating the screws, a cradle partly enclosing the tower section and threaded on the screws for vertical travel when they are rotated, and means extending inward from the cradle for detachable connection to the adjacent sides of the tower section to support it after it has been disconnected from the base member, whereby the tower section can be raised to make

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room for a similar tower section below it in the frame while the cradle is raised.

4. Tower erection apparatus according to claim 3, in which said inwardly extending means consist of pairs of arms pivoted on vertical axes, the inner ends of the arms in each pair being adapted to be swung toward each other beneath projections on the tower section.

5. Tower erection apparatus comprising a plurality of vertical jack screws, means for rotating the screws, lifting means threaded on the screws for vertical travel when they are rotated, means adapted to support an upright tower section from said lifting means to raise it, guy lines for connection to the tower above said screws, and means operatively connected with said lines and synchronized with said screw rotating means for paying them out at a predetermined rate as the tower is raised by said lifting means.

6. Tower erection apparatus comprising a plurality of vertical jack screws, means for rotating the screws, lifting means threaded on the screws for vertical travel when they are rotated, means adapted to support an upright tower section from said lifting means to raise it, guy lines for connection to the tower above said screws, a cable having a loop operatively connected with each line, and means driven by said screw rotating means and connected with the opposite ends of the cables for lengthening their loops at a predetermined rate relative to the rotation of the screws to pay out the guy lines as the tower is raised by said lifting means.

7. Tower erection apparatus comprising a plurality of vertical jack screws, means for rotating the screws, lifting means threaded on the screws for vertical travel when they are rotated, means adapted to support an upright tower section from said lifting means to raise it, conical pay-out and take-up drums, means operatively connected with said screw rotating means for rotating the drums at a predetermined speed relative to the screws, a cable wound on the pay-out drum and having its ends attached to the large ends of both drums, and connecting means carried loosely by a loop in the cable between the drums and adapted to be connected to a guy line secured to the tower above said screws, the taper and speed of the drums being such that as the cable is wound on the take-up drum from the pay-out drum while the tower is being raised by said lifting means, said cable loop can lengthen and permit said connecting means to move away from the drums in order to pay out the guy line at a predetermined rate.

8. Tower erection apparatus according to claim 7, including a clutch between said drum-rotating means and the drums, and means for disengaging the clutch to permit the drums to be turned by hand to wind a predetermined length of said cable from the pay-out drum to the take-up drum.

9. Tower erection apparatus comprising a plurality of vertical jack screws, means for rotating the screws, lifting means threaded on the screws for vertical travel when they are rotated, means adapted to support an upright tower section from said lifting means to raise it, conical pay-out and take-up drums, supporting means for the drums, means operatively connected with said screw

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rotating means for rotating the drums at a predetermined speed relative to the screws, a cable wound on the pay-out drum and having its ends attached to the large ends of both drums, a sheave adapted to be anchored to the ground a considerable distance from said screws, a guy line extending around said sheave and having its lower end adjacent said drums and having an upper end for connection to the tower above said screws, sighting means mounted on said drum-supporting means adjacent said screws for viewing and indicating the elevation of said sheave relative to the screws, the drums being rotatable in unison before said screws are turned to wind a predetermined length of said cable from the pay-out drum to the take-up drum in accordance with said relative elevation of the sheave, and a connecting member secured to the lower end of the guy line and slidably receiving the cable loop, the taper of the drums and their speed of rotation by said drum-rotating means being such that as more cable is wound on the take-up drum while the tower is being raised by said lifting means, the length of said cable loop can change and cause said connecting member to change its distance from the drums to keep the guy line under a predetermined tension as the tower is raised.

10. Tower erection apparatus according to claim 9, in which said sighting means is a tube pivotally mounted on a horizontal axis, with a scale beside it indicating by the inclination of the tube the amount of cable that should be wound from the pay-out drum to the take-up drum before the screws start to lift the tower.

11. Tower erection apparatus according to claim 9, including a pointer above one of said drums, means for moving the pointer lengthwise of the drum, and means indexed to said sighting means to indicate the proper position of the pointer along the drum.

12. Tower erecting apparatus comprising a base member, an upright frame removably mounted on the base member and having an open side for receiving an upright long tower section, a short tower section permanently mounted on said base member, tower-receiving clamps on the upper end of said short section adapted to detachably connect it to the bottom of the long section, a plurality of vertical jack screws rotatably mounted in the frame, means for rotating the screws, and lifting means adapted to partly surround the long tower section and threaded on the screws for vertical travel when they are rotated, said lifting means including means adapted to be connected to the outside of the long tower section in said lifting means after that section has been released from said tower-receiving clamps, whereby the long tower section can be raised and supported by the lifting means while a similar tower section is inserted between it and said short tower section.

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