

May 19, 1959

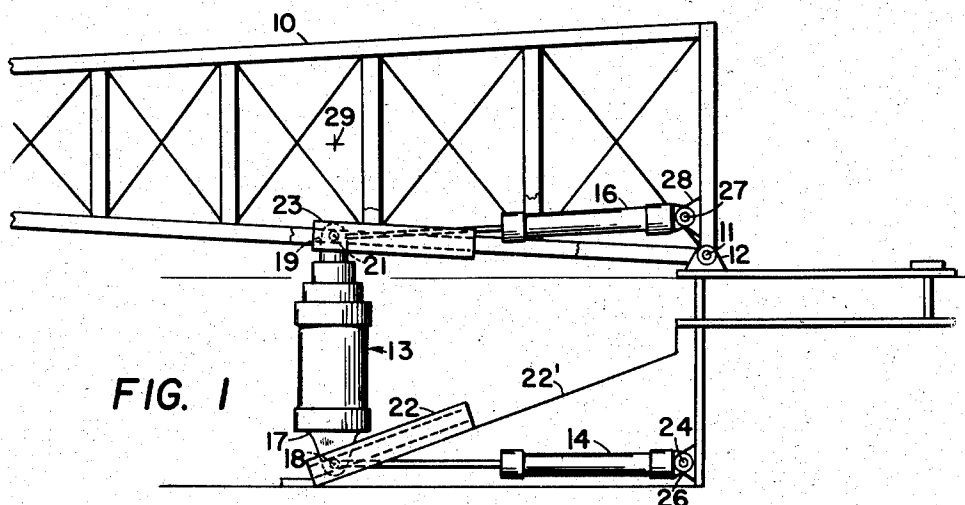
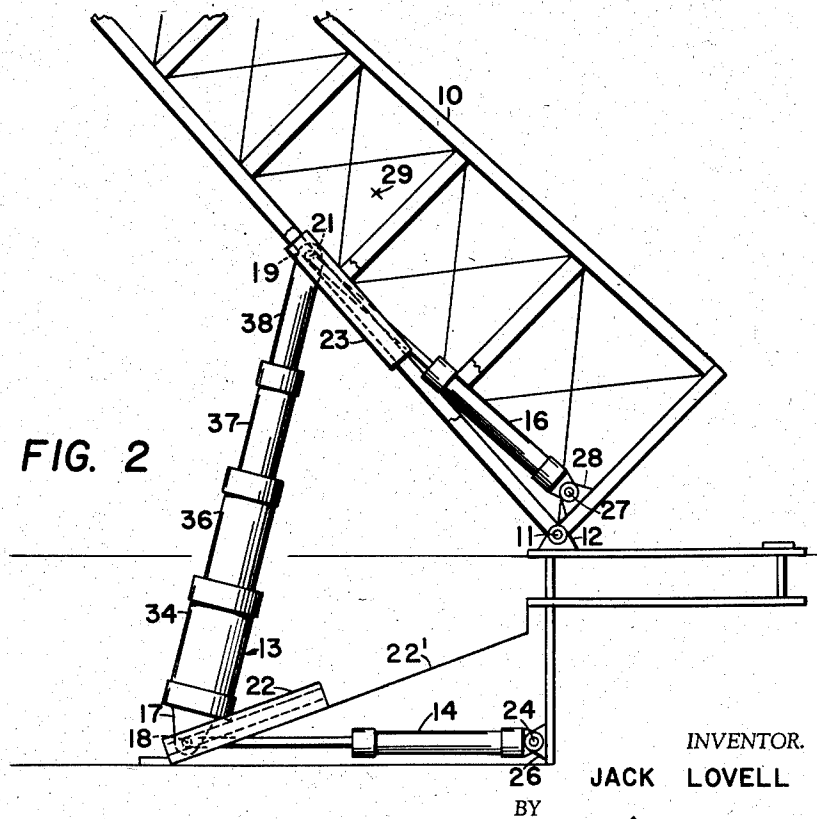
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2,887,191

TOWER RAISING MECHANISM

Filed Oct. 7, 1957

4 Sheets-Sheet 1



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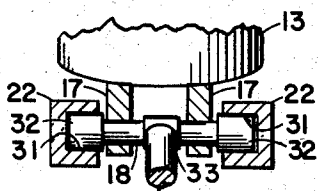


FIG. 4

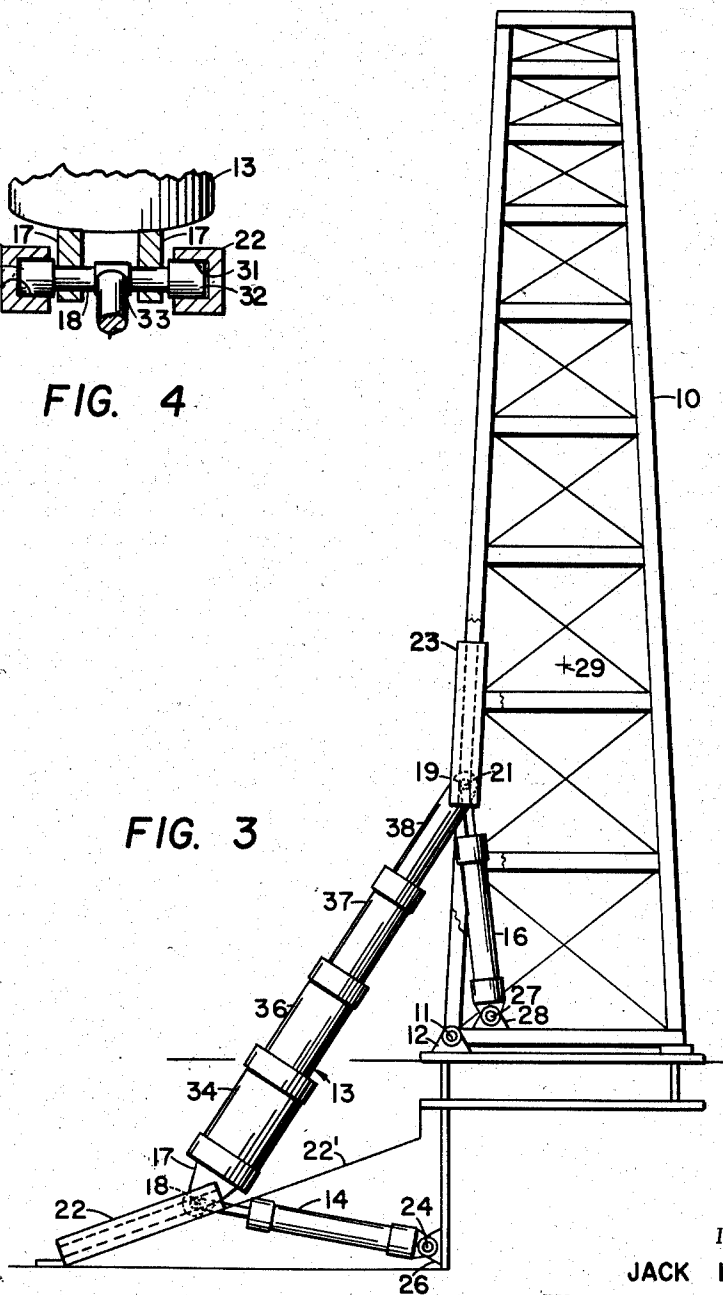


FIG. 3

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4 Sheets-Sheet 3

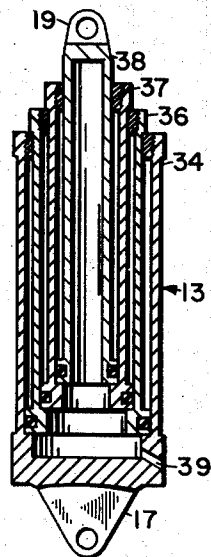


FIG. 5

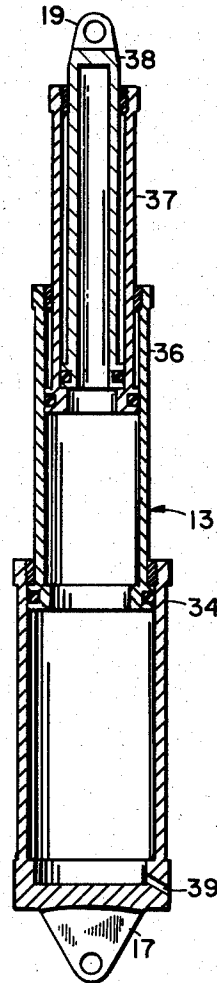


FIG. 6

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TOWER RAISING MECHANISM

4 Sheets-Sheet 4

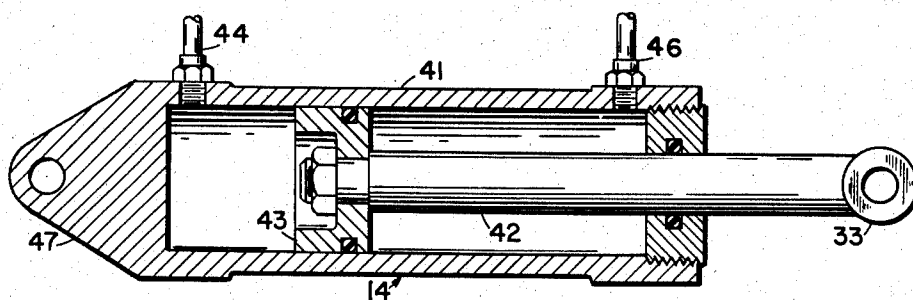


FIG. 7

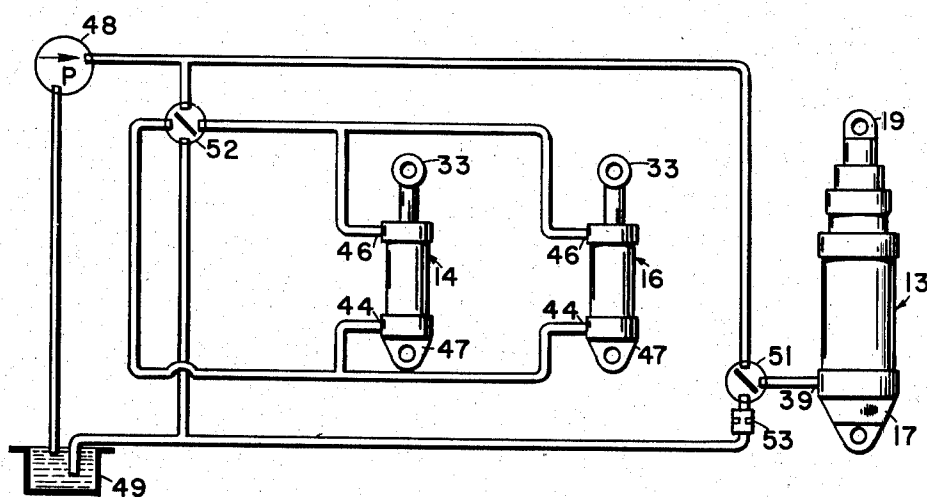


FIG. 8

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2,887,191

TOWER RAISING MECHANISM

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7 Claims. (Cl. 189-15)

This invention relates to actuator systems in general and more particularly to an actuator system suitable for use in raising and lowering large towers and the like.

It is an important object of this invention to provide an actuator system for raising and lowering large structural members such as towers and the like.

It is another important object of this invention to provide actuator systems capable of raising and lowering towers and the like wherein a main multi-stage actuator is utilized to perform the initial tower raising operation and secondary smaller actuators are utilized to complete the raising operation.

It is still another object of this invention to provide an actuator system for raising and lowering of towers and the like wherein three separate actuators co-operate to accomplish the raising operation so that relatively small individual actuators can be used.

Further objects and advantages will appear from the following description and drawings, wherein:

Figure 1 is a schematic side elevation showing the tower and actuator system when the tower is in the lowered position;

Figure 2 is a view similar to Figure 1 showing the position the elements assume when the tower is in an intermediate raised position;

Figure 3 is a view similar to Figures 1 and 2 showing the positions of the elements when the tower is in the erected or raised position;

Figure 4 is an enlarged fragmentary view showing the main actuator mounting structure.

Figure 5 is a longitudinal section of the main actuator in the compressed or retracted position;

Figure 6 is a longitudinal section of the main actuator in a partially extended position;

Figure 7 is a longitudinal section of one of the secondary actuators; and,

Figure 8 is a schematic view showing a preferred hydraulic control system for operating the actuator system.

The actuator system according to this invention is particularly suitable for use in raising or lowering tower structures which are pivoted along one edge of their base for movement between a horizontal position lying along the ground and a vertical or erected position. Such towers find use in erecting guided missiles and the like which are normally transported and stored in a horizontal position but which must be raised to a vertical position before firing. The tower shown is merely a schematic illustration of one type of tower and could be used for missile applications or the like. The actuator system could be also utilized in any other combination wherein large structures are raised and lowered between a horizontal and a vertical position.

Referring to Figures 1 through 3 a tower structure 10 is provided with a pivot shaft 11 along one edge of its base. The pivot shaft 11 extends through pivot pads 12 which are mounted near or on the surface of the ground on a suitable foundation so that the tower

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can be raised and lowered between the horizontal position of Figure 1 to the vertical position of Figure 3. Three hydraulic piston and cylinder actuators co-operate to raise and lower the tower between the two positions of Figures 1 and 3 and include a main multi-stage actuator 13 and two secondary single-stage double-acting actuators 14 and 16. The lower end of the main actuator 13 is provided with laterally spaced mounting lugs 17 through which a pivot pin 18 projects and the upper end is provided with similar mounting lugs 19 through which a pivot pin 21 projects. The pivot pins 18 and 21 are each provided with bearings 32 which can roll axially along guide tracks 22 and 23 respectively wherein the track 22 is rigidly mounted on a suitable ground foundation such as 22' and the track 23 is fixed on the frame of the tower 10 and both tracks 22 and 23 extend generally toward the pivot shaft 11. The secondary actuator 14 is pivoted at one end 24 to a fixed pivot block 26, located below the base of the tower, and at the other end to the pivot pin 18. The secondary actuator 16 is pivotally connected at one end 27 to a pivot block 28 mounted on the base of the tower 10 and at its other end to the pivot pin 21.

When the tower 10 is in the lower position the two secondary actuators 14 and 16 are extended and the main actuator 13 is compressed. In order to raise the tower hydraulic fluid under pressure is supplied to the main actuator 13 which causes it to extend from the position of Figure 1 to Figure 2. At this time the tower is raised through approximately 45° from the horizontal position and the main actuator 13 is fully extended. The two secondary actuators 14 and 16 are then pressurized to move the pivot pins 18 and 21 along their respective tracks 22 and 23 toward the tower pivot shaft 11 to complete the raising operation to the position of Figure 3. An inspection of Figure 3 will show that when the tower is in the vertical position the two secondary actuators 14 and 16 are compressed and the main actuator 13 is in its extended position. It should be understood that the function of the secondary actuators 14 and 16 is to move the ends of the main actuator 13 along the tracks to change the spacing of the main actuator 13 and pivot shaft 11 so the secondary actuators can be connected directly to the main actuator 13 or in any other way to perform that function.

By utilizing this system it is possible to use a relatively short main actuator 13 and still maintain the lifting point well out from the main tower pivot 11 during the initial raising of the tower when the loads are greatest. Those skilled in the art will recognize that the load on the main actuator 13 is an inverse function of the spacing between the tower pivot shaft 11 and the point of connection of the main actuator 13 to the tower when the axis of the main actuator is perpendicular to the tower as shown. If the center of gravity of the tower 10 is located at 29, the preferred actuator system permits the location of the lift point under or outward from the center of gravity during the initial raising operation while still permitting the stroke of the main actuator 13 to be relatively short. Once the tower is raised to the position of Figure 2 the effective moment of the center of gravity 29 is smaller and the smaller secondary actuators 14 and 16 will provide sufficient force to raise the tower.

When the tower is to be lowered from the raised position of Figure 3 it is merely necessary to supply hydraulic pressure to the secondary actuators 14 and 16 to extend them moving the pivot pins 18 and 21 outwardly along the tracks 22 and 23 respectively. Such extension of the secondary actuator provides sufficient movement of the tower to move the center of gravity over the tower pivot pin 11 at which time weight of

the tower will produce a compressive force on the main actuator 13. After the secondary actuators are fully extended, motive fluid is gradually released from the main actuator 13 and the weight of the tower causes the actuator to compress while the tower is being lowered to the horizontal position of Figure 1.

Preferably, the guides on tracks 22 and 23 are of similar structure so only the track 22 and its connection with the actuators 13 and 14 will be discussed in detail. Referring to Figure 4 the track 22 is formed with two opposed inwardly facing channels 31 which are supported on the ground by any suitable means. The pivot pin 18 extends into the channels 31 and is provided with a load bearing 32 at each end which rolls along the corresponding channel 31. The actuator 14 is provided with a journal end 33 which connects to the shaft 18 between the mounting lugs 17 of the main cylinder 13.

A preferred structure of the main actuator 13 is shown in Figures 5 and 6 and includes a lower cylinder 34 into which telescopes a first intermediate sleeve 36. A second intermediate sleeve 37 in turn telescopes in the first sleeve 36 and telescoping into the second intermediate sleeve 37 is a piston 38. The piston 38 and the two intermediate sleeves 36 and 37 all contained within the cylinder 34 when the actuator 13 is compressed so the actuator 13 will compress to a short length when compared with its stroke. Suitable seals are provided between the cylinder 34, sleeves 36 and 37 and the piston 38 to prevent leakage.

When fluid under pressure is supplied to the cylinder 34 through an inlet port 39 the intermediate sleeve 34 moves outwardly out of the cylinder 34 carrying with it the intermediate sleeve 37 and the piston 38. When the first intermediate sleeve 36 is fully extended the second intermediate sleeve 37 starts to move relative thereto carrying with it the piston 38, as shown in Figure 6. This continues until the piston 38 and the two intermediate sleeves 36 and 37 are fully extended. During the lowering of the tower the fluid can be metered out of the port 39 to control the rate of compression of the main actuator 13 and in turn the rate of lowering of the tower.

A normal piston and cylinder structure is preferably used for the secondary actuators 14 and 16 and since both of the secondary actuators have the same structure only the secondary actuator 14 is shown in Figure 7. The actuator 14 has a cylinder 41 into which projects a piston rod 42 on which is mounted a piston head 43. Since the secondary actuator operates to initiate the lowering of the tower it must be double acting so the cylinder is provided at opposed ends with supply ports 44 and 46, respectively. If fluid under pressure is supplied through the port 44 and the port 46 is connected to the reservoir return the piston rod 42 extends. Conversely, if the opposite fluid connection is made the piston rod 42 moves to the left toward the compressed position. The journal end 33 which connects to the pivot pin 18 is formed on the piston rod and the cylinder 41 is provided with a mounting lug 47 which connects to the pivot 24. Normally, the piston and cylinder fluid motor shown will be used as the secondary actuators 14 and 16. However, it should be understood that any other suitable mechanism may be utilized, such as a rack and pinion, chain or cable drives. It is important, however, that the secondary actuators be double acting so that they can initiate lowering of the tower.

In Figure 8 a preferred control system for the actuators is schematically shown. In this case a pump 48 receives hydraulic fluid from a reservoir 49 and delivers the hydraulic fluid under pressure to first and second control valves 51 and 52. The control valve 51 selectively connects the main actuator 13 to the pump 48, if it is to extend, or to the reservoir 49, if it is to compress. A flow restriction or orifice schematically shown at 53 may be connected in the return line from the main actuator 13 to the reservoir 49 to control the rate for compression to the actuator.

The control valve 52 is of a standard 4-way type and is arranged to selectively connect the two ends of the actuator to either the pump 48 or the reservoir return. If the valve 52 is in the position shown the pump is connected to the ports 46 of the two cylinders 14 and 16 which are connected in parallel and the ports 44 are both connected to the reservoir 49. When this connection is made the two actuators 14 and 16 will compress. Operation of the 4-way valve 52 to the other position will cause the opposite fluid connections and extension of the two actuators 14 and 16. If individual control is to be provided for each of the actuators 14 and 16 it is merely necessary to provide a separate 4-way valve for each actuator. However, it is contemplated in most cases for the two actuators 14 and 16 to be connected in parallel.

By utilizing the actuator system according to this invention it is possible to locate the main actuator 13 sufficiently far out on the tower to reduce the initial loads without requiring the use of an extremely long actuator. Because the main actuator 13 for a given application need not be as long, a simple structure may be used with a smaller number of telescoping sleeves. In the illustrated embodiment a triple extension actuator is shown, but if this were the only actuator it would have to have at least twice as many stages. Those skilled in the art will recognize that such stages vastly complicate the system and increase the possibility of failure. Again, since the secondary actuators 14 and 16 commence to operate only after the tower 10 is partially raised smaller actuators can be used because the effective moment arm of the tower center of gravity is reduced. Still another advantage is derived from the fact that the multi-stage main actuator 13 need not be double acting to initiate lowering of the tower.

Although the preferred embodiment of this invention is illustrated, it will be realized that various modifications of the structural details may be made without departing from the mode of operation and the essence of the invention. Therefore, except insofar as they are claimed in the appended claims, structural details may be varied widely without modifying the mode of operation. Accordingly, the appended claims and not the aforesaid detailed description is determinative of the scope of the invention.

I claim:

1. In a device of the character described a member pivoted for rotation around an axis, a first actuator having two elements movable relative to each other, a first guide fixed relative to said axis, a second guide mounted on said member, a first bearing means connecting one of said elements to said first guide, second bearing means connecting the other of said elements to said second guide whereby relative movement between said elements effects partial rotation of said member around said axis, and second actuator means connected to said first and second bearing means operable to move both of said bearing means along their associated guides changing the spacing between said axis and both of said bearing means thereby effecting additional rotation of said member around said axis.

2. An actuator system for rotating an elongated structure about a pivot between a lowered and raised position comprising a first guide fixed relative to said pivot, a second guide mounted on said structure, a first actuator including two elements movable relative to each other, first bearing means connecting one of said elements to said first guide, second bearing means connecting the other of said elements to said second guide, a second actuator connected to the first bearing means operable to move it along said first guide changing the spacing between said pivot and first bearing means, third actuator connected to said second bearing means operable to move it along said second guide changing the spacing between said pivot and second bearing means.

3. An actuator system for rotating an elongated struc-

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ture around a pivot between a raised and a lowered position comprising an actuator having two telescoping elements axially movable relative to each other between a compressed and extended position, first means connecting one of said elements to a fixed support, second means connecting the other of said elements to said structure, said actuator being compressed when said structure is in said lowered position, relative movement between said elements to said extended position rotating said structure in an intermediate position between said raised and lowered positions, and power means operably connected to said first and second connecting means for effecting movement of said actuator toward said pivot thereby rotating said structure from said intermediate position to said raised position while said actuator is in said extended position.

4. An actuator system for rotating an elongated structure around a pivot between a raised and a lowered position comprising an actuator having two telescoping elements axially movable relative to each other between a compressed and extended position, first means connecting one of said elements to a fixed support, second means connecting the other of said elements to said structure, said actuator being compressed when said structure is in said lowered position with its axis substantially perpendicular to said structure, relative movement between said elements to said extended position rotating said structure to an intermediate position between said raised and lowered positions, and power means operably connected to said first and second connecting means for effecting movement of said actuator toward said pivot thereby rotating said structure from said intermediate position to said raised position while said actuator is in said extended position.

5. An actuator system for rotating an elongated structure around a pivot between a raised and a lowered position comprising an actuator having two telescoping elements axially movable relative to each other between a compressed and extended position, first means connecting one of said elements to a fixed support, second means connecting the other of said elements to said structure, said actuator being compressed when said structure is in said lowered position with its axis substantially perpendicular to said structure, relative movement between said elements to said extended position rotating said structure in an intermediate position between said raised and lowered positions, and power means operably connected to said actuator for effecting movement thereof toward said pivot while said actuator is in said extended position thereby rotating said structure from said intermediate position to said raised position, said power means being operable to move said actuator away from said piston to initiate movement of said structure from said raised position toward said lowered position.

6. An actuator system for rotating a tower around a pivot between a horizontal position and a vertical position comprising a first track fixed relative to said pivot, a second track mounted on said tower, both of said tracks extending generally toward said pivot, first actuator having piston and cylinder elements axially movable rela-

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tive to each other between a compressed and extended position, said first actuator being operable to produce only a force urging said elements toward said extended position, first bearing means connecting one of said elements to said first track for movement therealong between first and second positions, second bearing means connected to the other of said elements to said second track for movement therealong between first and second positions, a second actuator connected to said first bearing means operably to move it in both directions between its first and second positions, a third actuator connected to said bearing means operable to move it in both directions between its first and second positions, said first and second bearing means being in their respective first positions with said first actuator in said compressed position when said tower is in said lowered position, movement of said first actuator to its extended position while said bearing means are in their respective first positions rotating said tower to an intermediate position between said raised and lowered positions, and movement of said bearing means to their second respective positions under the influence of said second and third actuators while said first actuator is in its extended position effecting movement of said tower from said intermediate position to said raised position.

7. An actuator system for rotating a tower around a pivot between a horizontal position and a vertical position comprising a first track fixed relative to said pivot, a second track mounted on said tower, both of said tracks extending generally toward said pivot, first actuator having piston and cylinder elements axially movable relative to each other between a compressed and extended position, said first actuator being operable to produce only a force urging said elements toward said extended position, first bearing means connecting one of said elements to said first track for movement therealong between first and second positions, second bearing means connected to the other of said elements to said second track for movement therealong between first and second positions, a second piston and cylinder actuator connected to said first bearing means operable to move it in both directions between its first and second positions, a third piston and cylinder actuator connected to said bearing means operable to move it in both directions between its first and second positions, said first and second bearing means being in their respective first positions with said first actuator in said compressed position when said tower is in said lowered position, movement of said first actuator to its extended position while said bearing means are in their respective first positions rotating said tower to an intermediate position between said raised and lowered positions, and movement of said bearing means to their respective second positions under the influence of said second and third actuators while said first actuator is in its extended position effecting movement of said tower from said intermediate position to said raised position.

References Cited in the file of this patent

FOREIGN PATENTS

52,541 France ----- June 5, 1944

UNITED STATES PATENT OFFICE
CERTIFICATION OF CORRECTION

Patent No. 2,887,191

May 19, 1959

Jack Lovell

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

In the grant, lines 2 and 12, and in the heading to the printed specification, lines 3 and 4, name of assignee, for "Chicago Pneumatic Industries Inc.", each occurrence, read -- Cleveland Pneumatic Industries Inc. --.

Signed and sealed this 25th day of April 1961.

(SEAL)

Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents