

Jan. 31, 1956

E. J. ARPS

2,732,992

AERIAL EXTENSION LADDER

Original Filed Sept. 28, 1946

4 Sheets-Sheet 1

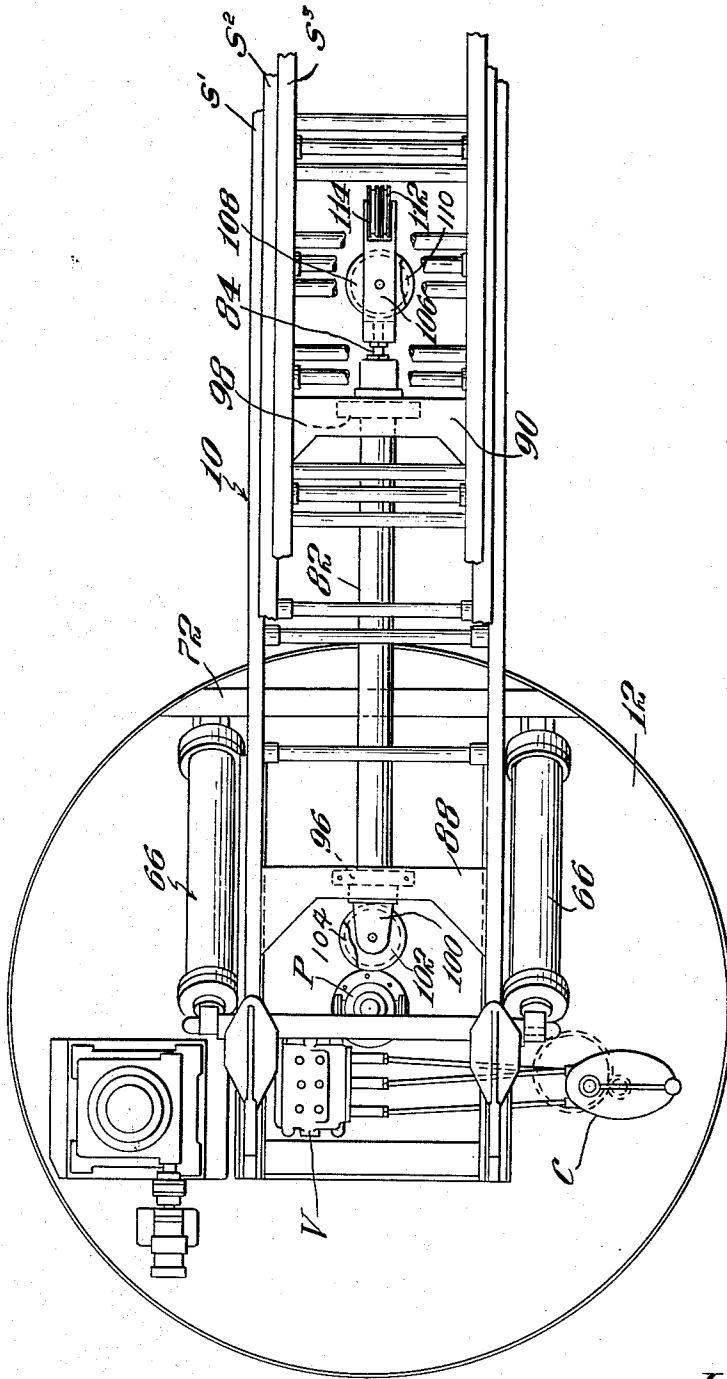


Fig. 1

Inventor
Edmund J. Arps
by Robert, Cushman & Groves
Att'ys.

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E. J. ARPS

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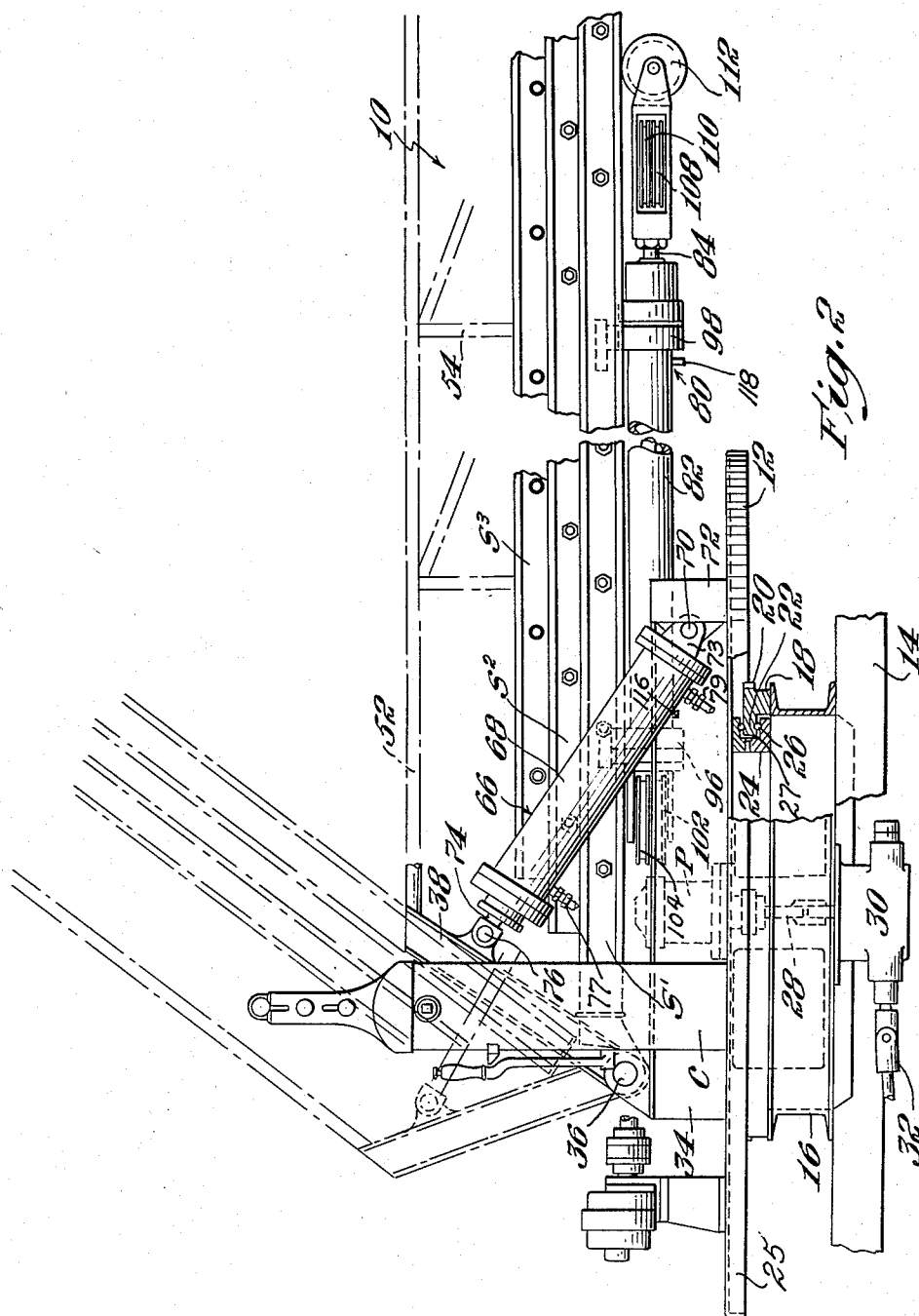


Fig. 2

Inventor
Edmund J. Arps
by Roberts, Cushman & Grover
Att'ys.

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E. J. ARPS

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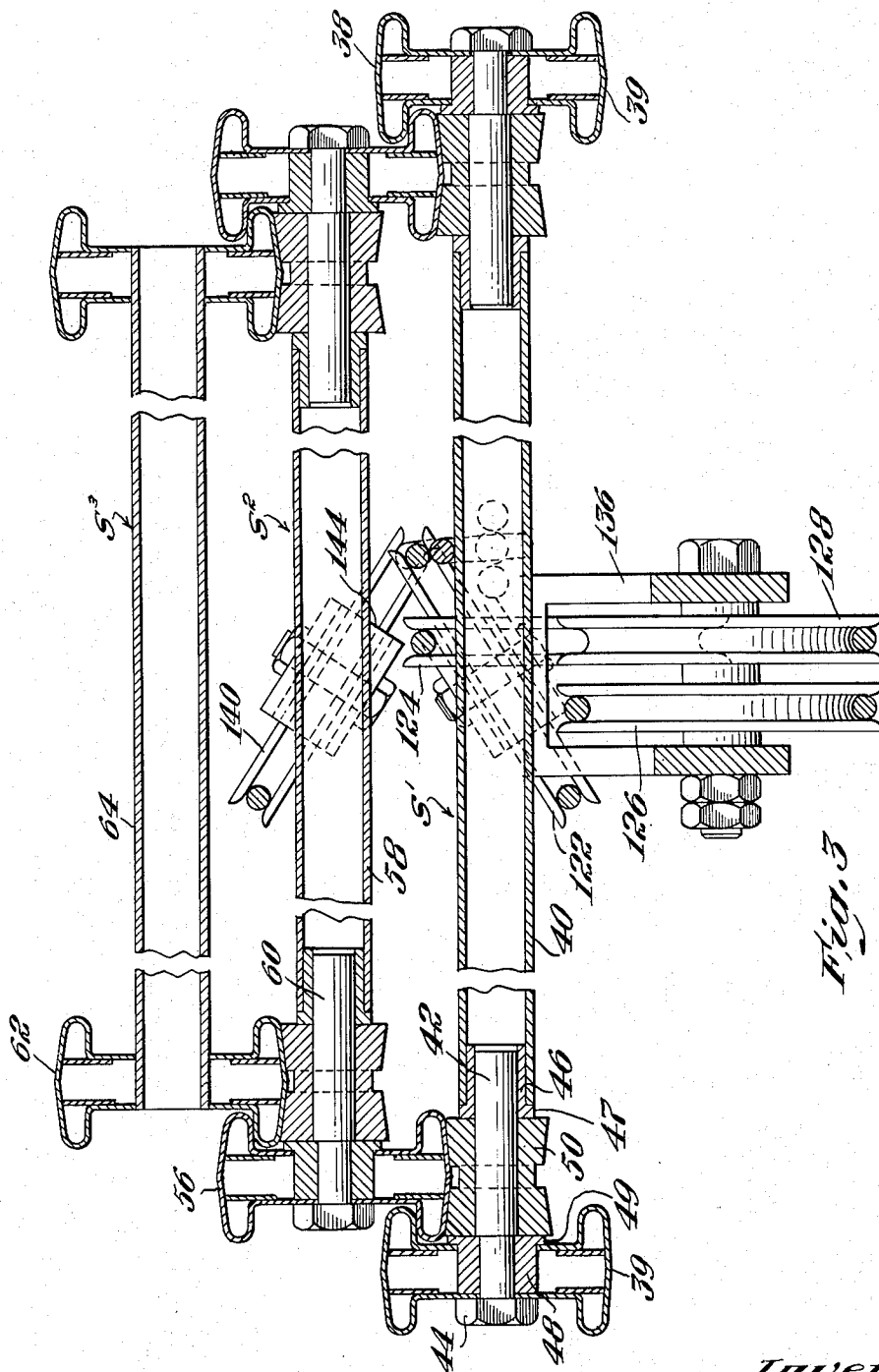


Fig. 3

Inventor
Edmund J. Arps
by Robert Cushman & Groves
att'ys.

Jan. 31, 1956

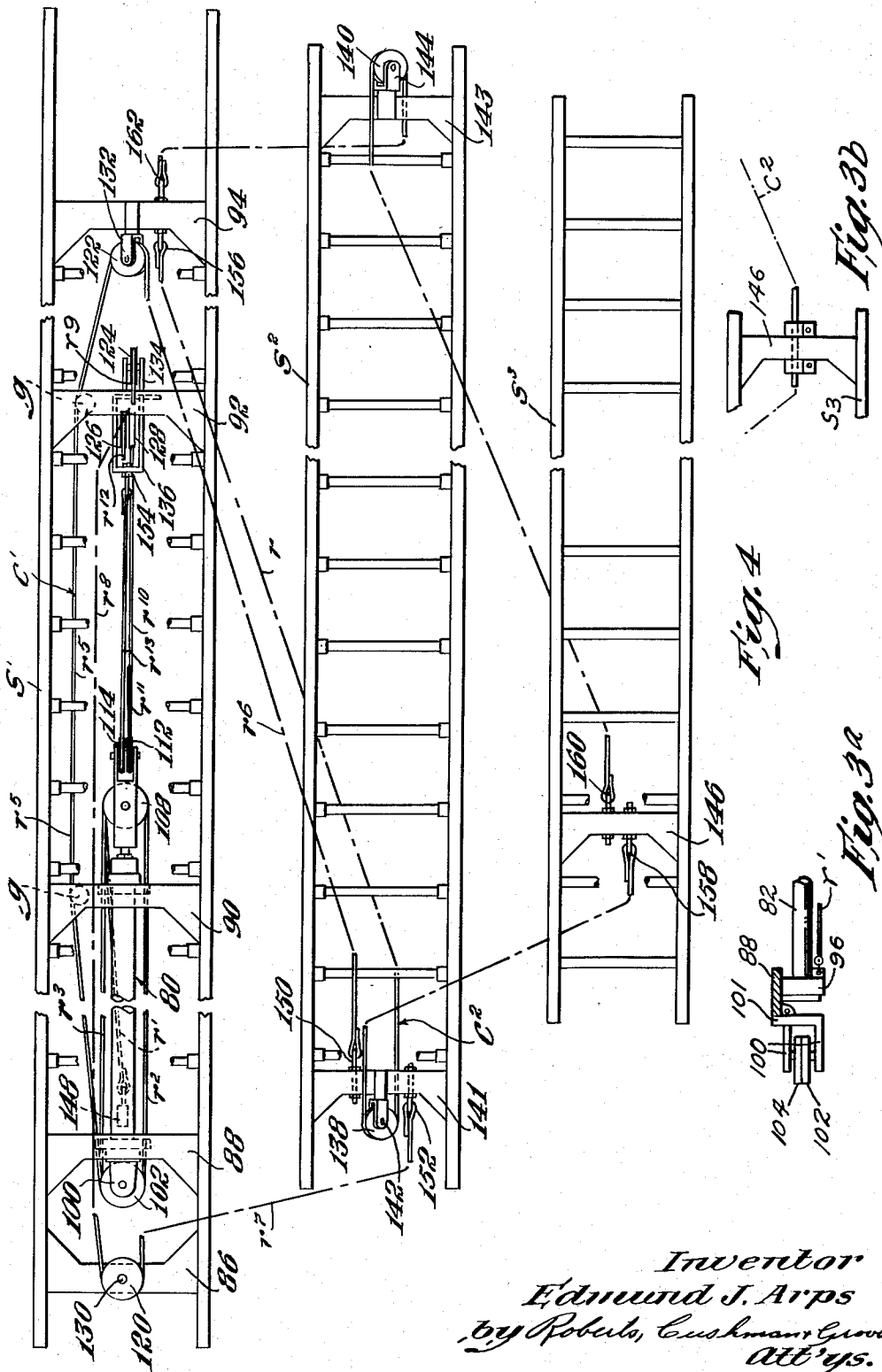
E. J. ARPS

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2,732,992

AERIAL EXTENSION LADDER

Edmund J. Arps, Oshkosh, Wis., assignor to Maxim Motor Company, Middleboro, Mass., a corporation of Massachusetts

Original application September 28, 1946, Serial No. 700,039, now Patent No. 2,614,743, dated October 21, 1952. Divided and this application July 11, 1952, Serial No. 298,396

13 Claims. (Cl. 228—9)

This invention relates to aerial ladders for fire apparatus and more especially to extension ladders and their operation.

Heretofore, extension and retraction of sections of aerial ladders have been effected by cables placed about pulleys carried by these sections, the cable being taken up and let out by a winch located at the base of the ladder and in other instances a piston and cylinder assembly has been employed in which the stroke of the piston was depended upon to take up or let out sufficient cable to effect necessary extension and retraction of the ladder sections. The chief disadvantages of the foregoing are the excessive space requirement to accommodate the mechanism, the comparatively slow speed of extension and retraction and the pronounced tendency for bowing of the ladder sections which if not compensated for by increasing the section modulus or by extensive reinforcement causes binding so that the sections will not slide freely.

The principal objects of this invention are to provide for compactness without sacrificing in any degree the amount of extension which may be obtained, to minimize bowing of the sections as they are extended and retracted without increasing the section modulus of the side rails of the ladder sections or adding stiffening or reinforcing members and hence to insure ease of sliding movement of the section and to provide for rapid extension and retraction.

As herein illustrated a plurality of ladder sections are slidably connected to each other so as to slide one upon the other from a retracted position in which they are superposed to an extended position in which they are substantially end to end, a minimum overlap at the ends when extended of course being maintained to insure rigidity. Extension and retraction is effected by a cable system, control of which is effected by a power cylinder, the latter being mounted on the lowermost ladder section at its base so as to be contained within the cable system. The power cylinder has a piston rod movable in its stroke parallel to the plane of the section and substantially midway between its side rails. The cable system is connected to the piston rod for effecting extension and retraction of the ladder sections and includes pulleys fast to the ladder sections carrying lengths of cable for multiplying the stroke of the piston rod and lengths of cable for transmitting the multiplied motion to the ladder sections. The multiplying lengths of the cable are mounted on multiple sheave pulley blocks, two of which are mounted on the lowermost ladder section and another of which is mounted on the piston rod and is located between the two so that extension of the piston extends the sections and retraction of the piston rod produces the opposite effect. The sheaves carrying the motion transmitting lengths of cable are connected to the ladder sections in such positions that the motion transmitting portion of the cable lies at opposite sides of the plane of the sections and hence the runs of the cable exert equal and opposite pulls on any given section and on the overall extended sections thereby eliminating any binding of the sections. The cable

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is so arranged as to multiply the stroke of the piston rod in the ratio of approximately 7 to 1. The power cylinder is located substantially in the plane of the lowermost ladder section and moves therewith so that regardless of the angular position of the ladder the pull exerted by the piston on the cable system is always in the same plane.

The invention will now be described in greater detail with reference to the accompanying drawings wherein:

Fig. 1 is a plan view of the turntable of a fire apparatus showing an aerial ladder in collapsed or retracted position and depressed so as to be substantially horizontal;

Fig. 2 is a side elevation of the turntable showing the ladder in a depressed position in full lines and partially elevated in dotted lines;

Fig. 3 is a vertical section transversely of the ladder sections when telescoped at the left side of the multiple-sheave pulley block near the upper ends of the lowermost ladder section to much larger scale showing the details of the ladder sections themselves and the pulley mountings;

Fig. 3a is a fragmentary side view partly in section showing means for fastening the multiple-sheave pulley at the lower end of the lowermost ladder section and the end of the cable to the ladder section rather than to the cylinder; and

Fig. 3b is a plan view of a fragmentary part of the uppermost ladder section showing an alternative anchorage for the extension cable fastened thereto.

Fig. 4 is a plan view of the ladder sections displaced laterally to show the path of the cable system.

Referring to the drawings, Figs. 1 and 2, there is shown an aerial ladder 10 mounted on a turntable 12 which in turn is mounted on a chassis 14 of a motor vehicle. The turntable 12 is supported for turning movement on the chassis by a platform base 16 made fast to the chassis. On the platform base 16 there is fastened a ring 18 having on its outer periphery gear teeth 20 and on its inner periphery a horizontal, inwardly extending lip 22. A ring 24 is made fast to the underside of the table and a ring 25 is fastened to the ring 24, the combined rings having in their opposing faces annular ways which together form an externally located groove 27 for the reception of the lip 22. There are grooves in the lip and in the walls of the groove 27 for receiving ball bearings 26 so that the table may turn on the base with the minimum amount of friction. Rotation of the table is effected as will appear by reference to my Patent No. 2,614,743, by a gear mounted on the underside of the table which meshes with the gear 20 which is driven by hydraulic means including a pump P mounted on the top of the table at the center of rotation thereof. The pump P is connected by a vertical shaft 28 including a suitable coupling to a gear reduction unit 30 fastened to the chassis 14 and this in turn is connected by a suitable coupling and shafts to a take off from the drive shaft of the motor vehicle. The foregoing pump P as appears in the application referred to above supplies hydraulic fluid under pressure to cylinders for raising and lowering the ladders and for effecting extension and retraction thereof. Valve and valve operating means V and C provide for control of the flow of fluid under pressure to the motor cylinders.

The extension ladder 10 consists of three sections S1, S2 and S3 and is pivotally mounted on the table 12 so as to be raised from a substantially horizontal position through approximately 90° to a nearly vertical position, the angle of elevation at any given time depending upon the particular conditions to be met. To this end there is made fast to the table spaced support members 34—34. The lower end of the lowermost ladder section S1 has fast to it bracket members 38—38 which are inclined to the ladder section as shown in Fig. 2 and these are pivotally secured to the members 34—34 at 36—36. Each section

has fastened to it handrails 52, the rails on the lower section being shown in dot and dash lines since the details of this structure are not necessary to a complete understanding of the invention.

The lowermost ladder section S1 (Fig. 3) consists of spaced parallel side rails 39—39 between which are fastened longitudinally spaced rungs 40 of tubular cross section. Each rung is fastened at its opposite ends to the side rails 39—39 by shafts 42 and nuts 44. A bushing 46 surrounds the inner end of each shaft 42, the bushing fitting into the open end of the rung and has a flange 47 at its outer end of substantially the same diameter as the rung. A bushing 48 is inserted through an opening in each side rail 38 so as to surround the shaft 42 and has a flange 49 at its inner end. Between the flanges 47 and 49 of the bushings 46 and 48 there is mounted on the shaft 42 a roller 50 and this as illustrated is adapted to receive the lower part of the side rail of the ladder section S2 which is mounted on the section S1 for reducing the frictional engagement of the sections as they slide on each other. The ladder section S2 corresponds in structure to that of the ladder section S1 having side rails 56—56 joined by rungs 58. Shafts 60 are provided for joining the rungs to the side rails and since they are substantially identical except for the fact that this section S2 is slightly smaller in width than the section S1 a further description is not deemed necessary. The ladder section S3 rests on the rollers of the section S2, is of narrower width and of somewhat different construction in that the rungs 64 are welded directly to the side rails 62—62.

The ladder sections S1, S2 and S3 are elevated and depressed as a unit by a pair of piston and cylinder assemblies 66 (Figs. 1 and 2) each of which consists of a power cylinder 68 and a piston to which there is fast a piston rod 74. A bar 72 is made fast to the turntable transversely thereof and the lower ends of the cylinders 66 are provided with spaced lugs 73 for receiving ears projecting forwardly from the bar and pivot pins 70. The free ends of the piston rods 74 which project from the upper ends of the cylinders are pivotally connected by pins 76 to the members 38—38. Suitable connections 77 and 79 are provided at opposite ends of the cylinders through which hydraulic fluid may be forced or exhausted for the purpose of positively elevating or depressing the ladder sections. The details of the hydraulic controls for effecting elevation and depression are described in the aforementioned application and hence need not be recounted herein.

Extension and retraction of the ladder sections is also effected hydraulically and as shown in Figs. 1, 2 and 4 the hydraulic means consists of a cylinder and piston assembly 80 which includes a cylinder 82 made fast to the lowermost ladder section from which projects a piston rod 84. Referring to Fig. 4, the lowermost ladder section S1 is shown as having transverse cross braces 86, 88, 90, 92 and 94. The cylinder 82 is fastened to the underside of the section S1 by brackets 96 and 98 mounted on the cross braces 88 and 90 with its longitudinal axis parallel to the center line of the ladder and with the piston rod extending toward the top of the section. At the lower end of the cylinder there projects a pair of spaced ears 100 which are formed integral with the cylinder and between these ears is mounted a pair of pulleys 102 and 104, the axis of rotation of the pulleys being perpendicular to the plane of the ladder. The ears and pulleys constitute a multiple sheave pulley block and while shown as part of the cylinder casting. Alternatively the ears 100 may be fastened to a bracket plate 101 (Fig. 3a) which in turn is fastened to the cross brace 88. At the free end of the piston rod 84 there is made fast a multiple sheave pulley block 106 in which there are mounted two pair of sheaves, a first pair 108, 110 and a second pair 112, 114. The axes of rotation of the sheaves 108, 110 are perpendicular to the plane of the ladder while the axes of rotation of the sheaves 112, 114 are parallel to the plane of the ladder. The cylinder is provided with suitable hydraulic connections 116 and 118 at its opposite ends for effecting move-

ment of the piston to extend or retract the piston rod and hence to increase or decrease the distance between the sheaves at the lower end of the cylinder and the sheaves carried by the piston rod. In addition to the sheaves carried by the cylinder and piston assembly there are mounted on the lowermost ladder section S1 single sheaves 120, 122 and 124 and a pair of sheaves 126 and 128. A pulley block fast to the cross brace 86 carries the sheave 120 for rotation about an axis perpendicular to the plane of the ladder. A sheave block 132 fast to the cross brace 94 carries the sheave 122 so that its axis is inclined to the plane of the ladder. The inclination of the axis of the sheave 122 to the plane of the ladder is shown in Fig. 3. A pulley block 134 fast to a cross brace 92 carries the sheave 124 so that its axis is parallel to the plane of the ladder. A multiple-pulley block 136 fast to the underside of the cross brace 92, carries the pair of sheaves 126, 128 for rotation about axes parallel to the plane of the ladder as shown in Fig. 3.

The ladder section S2 has sheaves 138 and 140 at its opposite ends made fast to cross braces 141 and 143 by pulley blocks 142 and 144 respectively so that their axes are inclined to the plane of the ladder, the inclination being shown in Fig. 3.

The ladder section S3 carries no pulleys whatever but does have a cross brace 146 for a purpose which will appear hereinafter.

The cable system for transmitting the motion or stroke of the piston rod 84 to the ladder sections in such fashion as to cause extension and retraction consists of two cables C1 and C2 mounted on the sheaves carried by the cylinder and piston assembly and the various ladder sections in the following fashion. One end of the cable C1 (Fig. 4) is made connected at 148 to the lower end of the cylinder 82 or to the cross brace 88 by way of the bracket 96 (see Fig. 3a) and extends to the right therefrom about the sheave 108 carried by the block 106 and constitutes a run r1 of the cable. The cable then passes around the sheave 108 and rearwardly, that is to the left as shown in Fig. 4 about the sheave 102 at the base of the cylinder forming a second run r2. From the sheave 102 the cable passes forwardly, that is to the right about the sheave 110 forming a third run r3, about the sheave 110 and rearwardly, that is to the left to the sheave 104 forming a run r4. The foregoing runs r1, r2, r3 and r4 constitute a part of the multiplying portion of the cable. From the sheave 104 the cable passes forwardly to the sheave 122 at the upper end of the lowermost ladder section forming a run r5 and then rearwardly to the left to the lower end of the ladder section S2 where it is connected at 150 to the cross brace 141 forming a run r6. A pair of guide rolls g—g mounted on the cross braces 90, 92 near one side provide for holding the run r5 laterally displaced from the center line of the ladder so that it will not become fouled with the multiplying runs at the center line of the ladder. An integral extension of the cable C1 or separate length thereof is also connected to the cross brace 141 at 152 and extends therefrom rearwardly about the sheave 120 on the lower end of the ladder section S1 forming a run r7. This then passes about the sheave 120 forwardly about the sheave 124 forming a run r8 from thence to the sheave 128 forming a run r9 then about the sheave 112 forming a run r10 then about the sheave 126 forming a run r11 then about the sheave 114 forming a run r12 and then back to the bracket 136 to which it is secured at 154 forming a run r13. The runs r5, r6, r7 and r8 constitute the motion transmitting portions of the cable C1. The runs r9, r10, r11, r12 and r13 constitute the remainder of the multiplying portions of the cable. The second cable C2 is made connected at one end at 156 to the cross brace 94, extends rearwardly therefrom about the sheave 138 at the lower end of the ladder section S2 and then forwardly and is connected at 158 to the lower cross brace 146 of ladder section S3. Either a continuation of this

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cable passing through the brace 146 and made fast by clamps 145 ((see Fig. 3b) or a separate length is connected at 160 (Fig. 4) to the cross brace 146 of the section S3, extends forwardly about the sheave 140 on the ladder section S2 then rearwardly and is connected at 162 to ladder section S1.

The important aspect of the present cable system is that its runs are contained wholly within the extremities of the ladder sections and that the power cylinder for taking up and letting out cable is also contained within the system, so as to provide a compact space saving arrangement of the cables and their operating mechanism for effecting extension and retraction of the ladder sections. Furthermore, the power cylinder is movable in elevation and depression with the ladder sections hence there is no change in the angle of pull exerted on the cable during elevation and depression. By locating the piston and cylinder assembly at the lower end of the lower ladder section and by carrying the cable about the cylinder the weight is kept at a low point hence keeping the center of gravity of the equipment as low as possible. The arrangement of the cable about the sheaves on the cylinder and piston assembly and on the ladder sections is such as to give a proportion of approximately 7 to 1, that is for every foot of cable taken up the ladder sections are extended seven feet.

The ladder section S2 travels faster than the pulley block 108 preferably at a ratio of about 4 to 1 so that the section S2 travels from its retracted position to its fully extended position rapidly. The ladder section S3 may be of the same length as the section S2 and because of the arrangement of the pulley block its travel will be the same as that of the section S2.

An important advantage of having the power cylinder contained within the cable system is that the effect of the extension of the piston rod is increased by the length of the cylinder in contrast to prior power cylinders wherein the cable does not pass about the ends of the cylinder, the pulley block being made fast to the piston rod and the cable having its origin at the piston rod end of the cylinder. In other words, heretofore, the power cylinder and piston lie entirely outside of the limits of the cable system.

It was pointed out above that certain of the sheaves to wit 122, 138 and 140 were mounted so as to be inclined to the plane of the ladder sections and this was done for the purpose of having the runs transmitting the motion to the section passing over these sheaves located at opposite sides of the plane of the ladder and thus to neutralize the forces in the runs which would tend to bow the ladder sections and hence to eliminate binding of the sections as they slide with reference to each other. by placing the sheaves as indicated the pull of the cable at one side of the extended ladder is substantially neutralized by that of the other side of the extended ladder and hence the forces at opposite sides are substantially balanced so that lighter sections may be employed.

With the foregoing arrangement of cables when the piston rod 84 is extended the runs between the sheaves 102, 104 and 108 are extended thereby taking up the runs between the sheaves 112, 114 and 126 and 128 rapidly, causing ladder section S2 to move rapidly toward the top of the ladder section S1. Movement of ladder section S2 simultaneously effects movement of the ladder section S3 toward its upper end through the medium of the cable system C2. The cables are so proportioned that the sections S2 and S3 reach their full extension substantially at the same time.

It should be understood that the present disclosure is for the purpose of illustration only and that this invention includes all modifications and equivalents which fall within the scope of the appended claims.

This application is a division of my Patent No. 2,614,743.

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I claim:

1. An aerial extension ladder comprising a plurality of ladder sections slidably connected together, multiple-sheave pulley blocks fast to the lowermost ladder section at longitudinally spaced points, a power cylinder containing a piston and rod fast to the lowermost ladder section between said spaced multiple-sheave pulley blocks, a multiple-sheave pulley block fast to the protruding end of the piston rod of the power cylinder and cable means having runs extending from the sheaves carried by the multiple-sheave pulley block fast to the piston rod to the sheaves carried by said spaced multiple-sheave pulley blocks, said cable means having ends connected to said lower ladder section with that portion intermediate its ends entrained about and free to run on the sheaves carried by said multiple-sheave pulley blocks, one run of the cable means extending about the sheaves on said spaced multiple-sheave pulley blocks having a portion of it connected to the lower end of the next ladder section, said power cylinder being operable to extend and retract the piston rod, extension of the rod moving the multiple-sheave pulley block carried thereby away from one of said spaced multiple-sheave pulley blocks and toward the other of said multiple-sheave pulley blocks and operating on the entrained cable means so as simultaneously to increase the length of the runs between the sheaves carried by one of said spaced multiple-sheave pulley blocks and the sheaves carried by the multiple-sheave pulley block fast to the piston rod, and to decrease the length of the runs between the sheaves carried by the other of said spaced multiple-sheave pulley blocks and the sheaves carried by the multiple-sheave pulley block fast to the piston rod.

2. An aerial extension ladder according to claim 1, wherein the multiple-sheave pulley block carried by the piston rod has two pairs of sheaves, one of the pair of said two pairs of sheaves carried by the piston rod and the sheaves carried by the multiple-sheave pulley block at the lower end of the power cylinder being mounted to turn on axes parallel to each other and perpendicular to the plane of the ladder section and the other pair of said two pairs of sheaves carried by the piston rod and the sheaves carried by the multiple-sheave pulley block at the upper end of the power cylinder being mounted to turn on axes parallel to each other and parallel to the plane of the ladder section.

3. An aerial extension ladder according to claim 1, wherein there are additional single-sheave pulley blocks fast to the lowermost ladder section at longitudinally spaced points beyond the multiple-sheave pulley blocks, over the sheaves of which that portion of the cable connected to the second ladder section is guided from the sheaves of the spaced multiple-sheave pulley blocks to said connector.

4. An aerial extension ladder according to claim 1, wherein there are additional single-sheave pulley blocks fast to the lowermost ladder section near the ends thereof beyond the spaced multiple-sheave pulley blocks, over the sheaves of which the cable runs from said spaced multiple-sheave pulley blocks, and is made fast to the second ladder section near its base, the sheave in the single-sheave pulley block at the base of the lowermost ladder section being mounted to turn on an axis perpendicular to the plane of the ladder and the sheave in the single-sheave pulley block near the top of the lowermost ladder section being mounted to turn on an axis inclined to the plane of said ladder section, the axes of all of said sheaves being disposed lengthwise of the ladder section along a line substantially midway between its side rails and close to the midplane of the section.

5. An aerial extension ladder according to claim 1, wherein there are longitudinally spaced single-sheave pulley blocks connected to the end portions of the second ladder section, and second cable means is connected to the upper end of the lowermost ladder section and the

lower end of the uppermost ladder section and passes over the sheaves carried by the spaced single-sheave pulley blocks connected to the ends of said second ladder section.

6. An aerial extension ladder according to claim 1, wherein there are longitudinally spaced single-sheave pulley blocks connected to the end portions of the second ladder section, and second cable means is connected to the upper end of the lowermost ladder section and the lower end of the uppermost ladder section and passes over the spaced sheaves carried by the spaced single-sheave pulley blocks, and that the sheaves carried by the single-sheave pulley blocks at the ends of the second ladder section are mounted to turn on axes parallel to each other and inclined to the plane of said second ladder section.

7. An aerial extension ladder comprising a plurality of ladder sections slidably connected together, first and second multiple-sheave pulley blocks fast to the one ladder section at longitudinally spaced points near the lower and upper ends respectively of said one ladder section, a power cylinder containing a piston and rod fast to said one ladder section between said spaced first and second multiple-sheave pulley blocks, a third multiple-sheave pulley block fast to the piston rod of the power cylinder, first and second single-sheave pulley blocks fast to said one ladder section at longitudinally spaced points beyond the first and second multiple-sheave pulley blocks, cable means having a portion connected to said one ladder section near the first multiple-sheave pulley block at the lower end of the power cylinder, said cable means passing from said point of connection about one spaced pair and then the other spaced pair of sheaves carried respectively by the one multiple-sheave pulley block at the lower end of the power cylinder and the third multiple-sheave pulley block carried by the piston rod, from said other spaced pair of sheaves to the single-sheave pulley block at the upper end of said one ladder section, from there back to the lower end of the next ladder section where it is connected to said next ladder section, from there to the single-sheave pulley block at the lower end of said one ladder section to the second multiple-sheave pulley block at the upper end of said one section, about a third spaced pair and then a fourth spaced pair of sheaves carried respectively by said second multiple-sheave pulley block and said third multiple-sheave pulley block and from thence to an anchorage on said one ladder section near the second multiple sheave pulley block.

8. An aerial extension ladder according to claim 7, wherein there is a single-sheave pulley block located adjacent the multiple-sheave pulley block at the upper end of the ladder section for receiving the run of the cable from the single-sheave pulley block at the lower end of the section and guiding it to the sheaves carried by the multiple-sheave pulley block at the upper end of the section.

9. An aerial extension ladder according to claim 7, wherein there are guide-rolls mounted on the ladder to turn on axes perpendicular to the plane of the ladder section, said guide-rolls being spaced laterally of the center line of the ladder section to guide the run of the cable from the multiple-sheave pulley block at the lower end of the cylinder to the single-sheave pulley block at the upper end of the section.

10. An aerial extension ladder comprising a plurality of sections slidably connected together, a power cylinder

including a piston and rod protruding therefrom connected to the lowermost ladder section, said cylinder and its piston rod being parallel to the center line of the ladder section, longitudinally spaced multiple-sheave pulley blocks fast to said lowermost ladder section, one at the lower end of the ladder near the lower end of the power cylinder and the other at the upper end of the ladder section, and a multiple-sheave pulley block carried by the piston rod alternatively movable toward one and away from the other of the spaced multiple-sheave pulley blocks at the lower and upper ends of the ladder and a cable system mounted to run on the sheaves of said multiple-sheave pulley blocks, there being a first series of runs extending between the sheaves on the multiple-sheave pulley block carried by the piston rod and the sheaves carried by the multiple-sheave pulley block at the lower end of the ladder and a second series extending from the sheaves carried by the multiple-sheave pulley block on the piston rod to the sheaves carried by the multiple-sheave pulley block at the upper end of the ladder section, said first and second runs being alternatively lengthened and shortened by the movement of the piston rod.

11. An aerial extension ladder comprising a plurality of sections slidably connected together, cable means and power operated means connected thereto for effecting extension and retraction of the sections, said cable means having motion transmitting portions interconnecting the ladder sections and a multiplying portion for multiplying the motion applied to the transmitting portion by the power operated means, said transmitting portions being disposed so that an equal number of runs of the cable means lie at opposite sides of the plane of each ladder section.

12. An aerial extension ladder comprising first, second and third sections slidably connected together, cable means and power operated means connected thereto for effecting extension and retraction of the sections, single-sheave pulleys mounted on the first and second ladder section near their opposite ends, said cable means having motion transmitting runs interconnecting the ladder sections running on the sheaves of said single-sheave pulleys, multiple-sheave pulley blocks mounted on the first ladder section, a multiplying portion of the cable means running on the sheaves of said multiple-sheave pulleys for multiplying the motion applied to the transmitting portion by the power operated means, the sheaves of the pulleys near the ends of the first and second sections being disposed so that the motion transmitting runs lie at opposite sides of the planes of said first and second sections, and cable ends running from said second section to the lower end of the third section and being connected thereto.

13. An aerial extension ladder according to claim 12, wherein the pulleys at the ends of the first and second ladder sections are inclined to the plane of said sections so that the runs of the cable passing over the sheaves will lie at equal distances at opposite sides of the planes of said sections.

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