Sept. 27, 1955 J. OPPENHEIMER 2,719,043

MOVABLE SUPPORTING STRUCTURES

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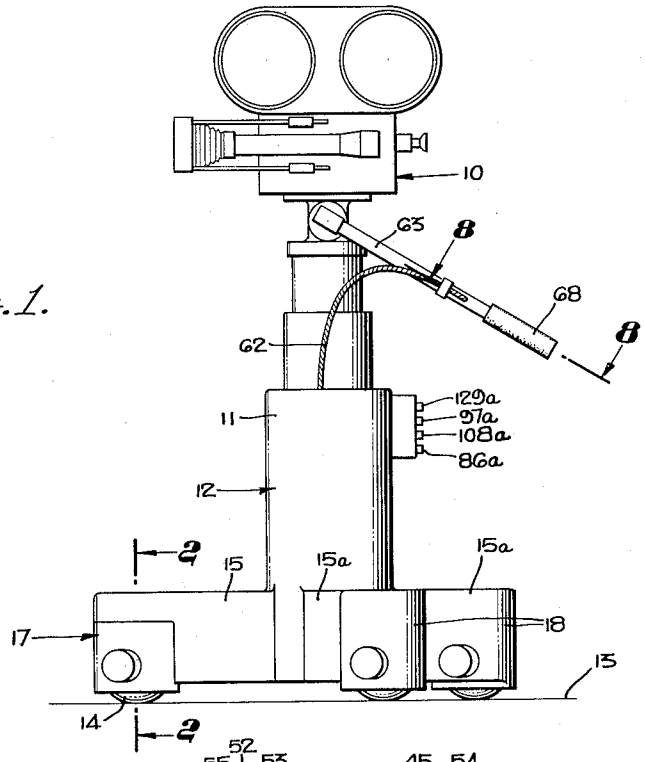
FIG. 1.



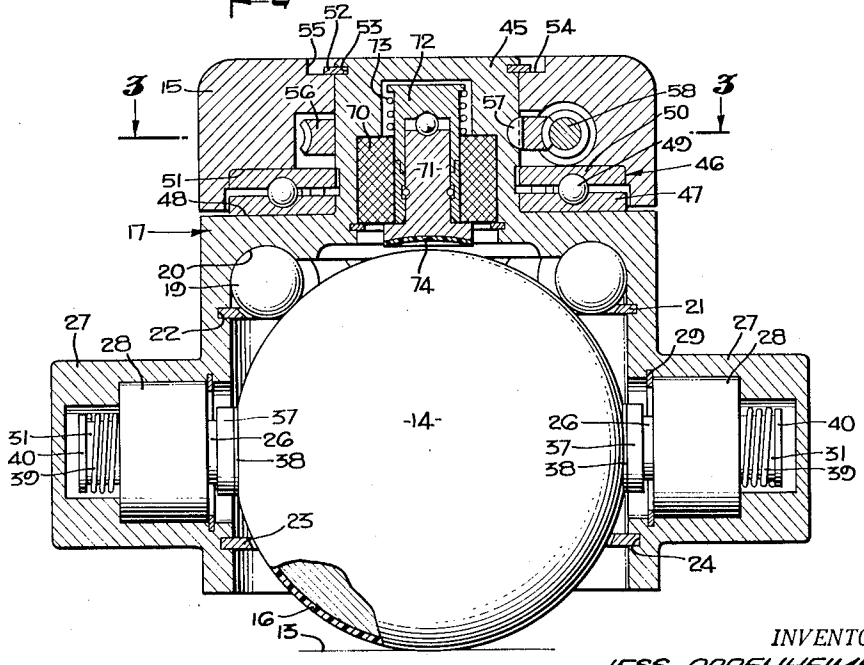


FIG. 2.

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MOVABLE SUPPORTING STRUCTURES

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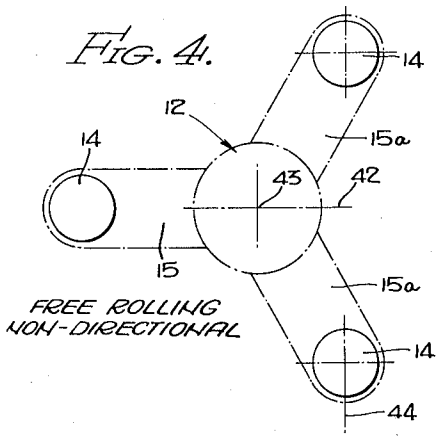
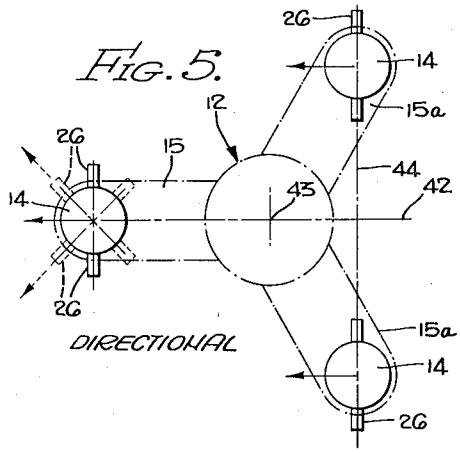
FIG. 4.



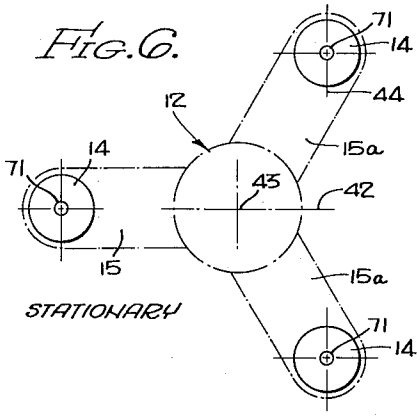
FREE ROLLING NON-DIRECTIONAL

FIG. 5.



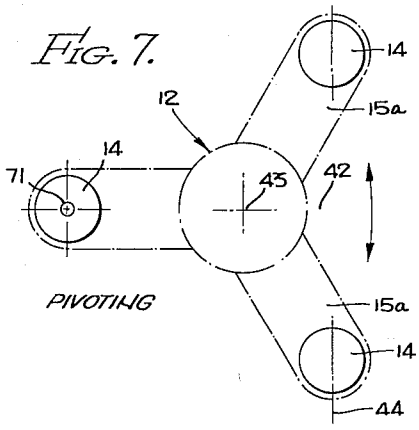
DIRECTIONAL

FIG. 6.



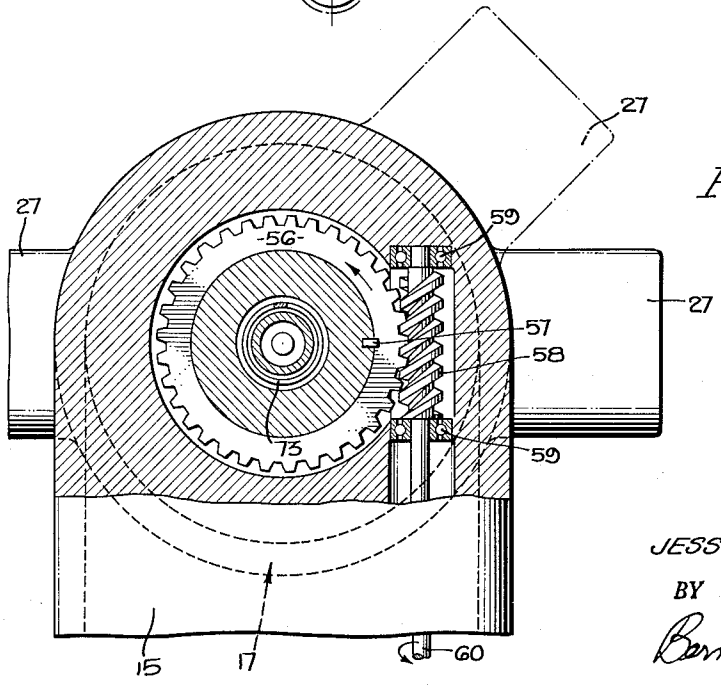
STATIONARY

FIG. 7.



PIVOTING

FIG. 3.



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MOVABLE SUPPORTING STRUCTURES

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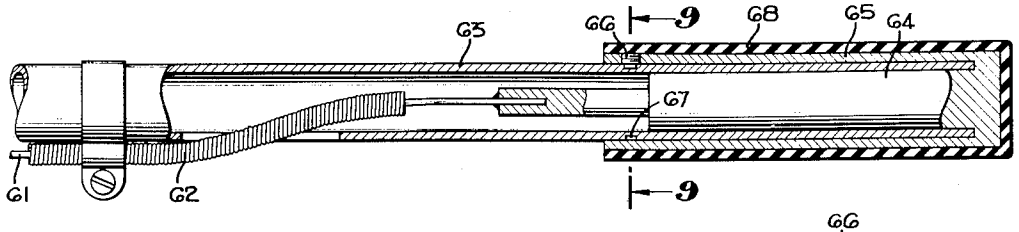

FIG. 8.

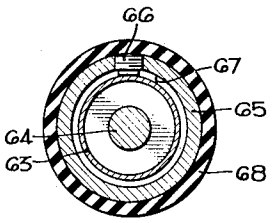

FIG. 9.

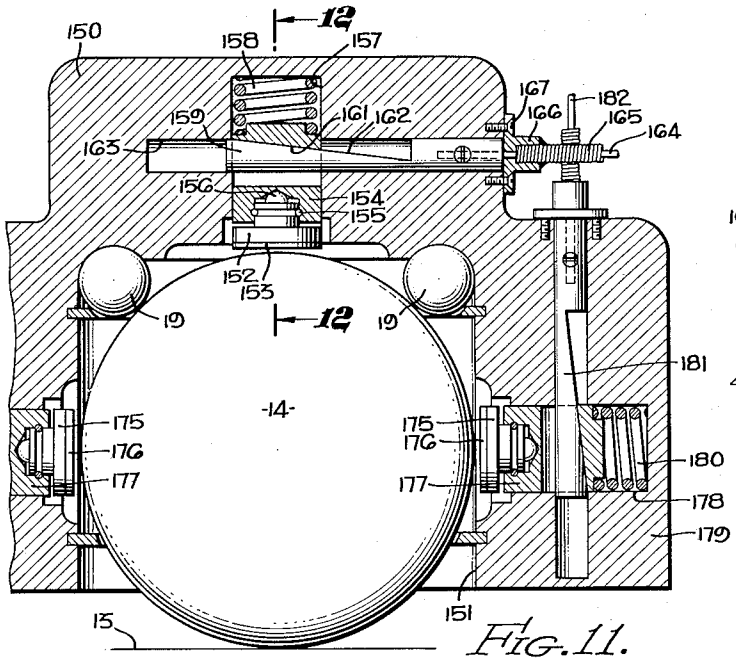

FIG. 11.

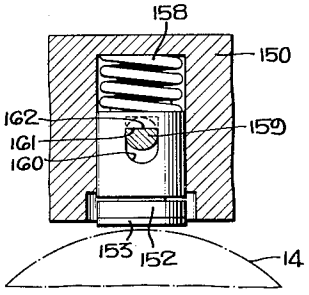

FIG. 12.

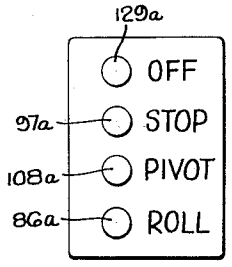

FIG. 10.

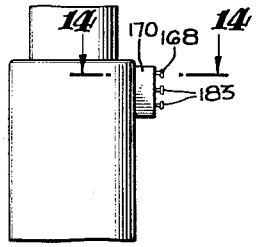

FIG. 13.

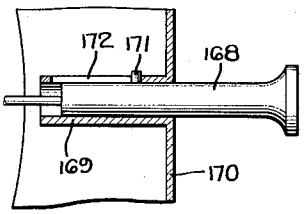

FIG. 14.

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FIG. 15.

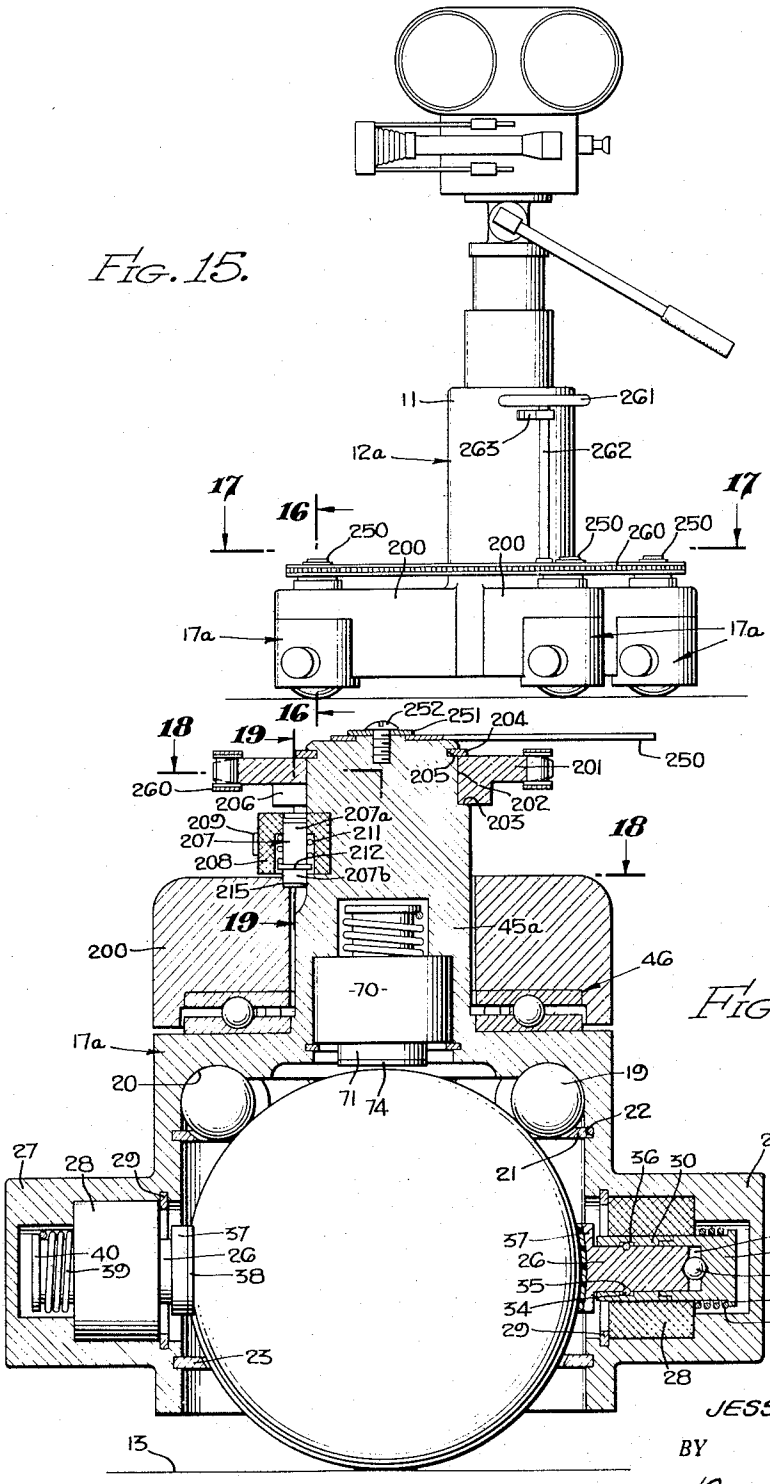

FIG. 16.

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MOVABLE SUPPORTING STRUCTURES

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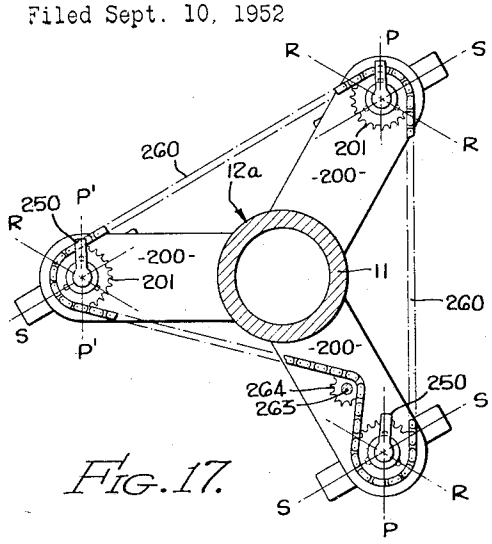

FIG. 17.

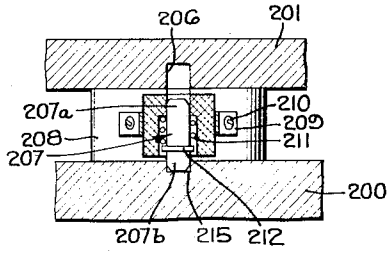

FIG. 19.

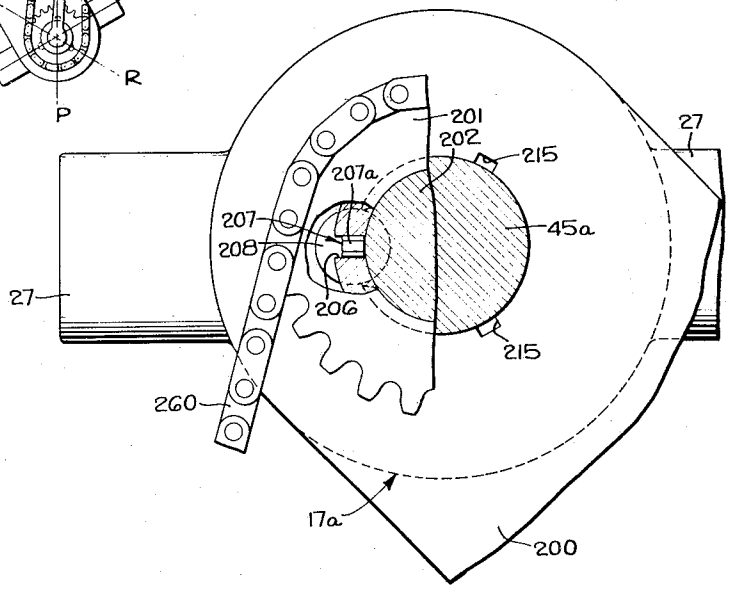

FIG. 18.

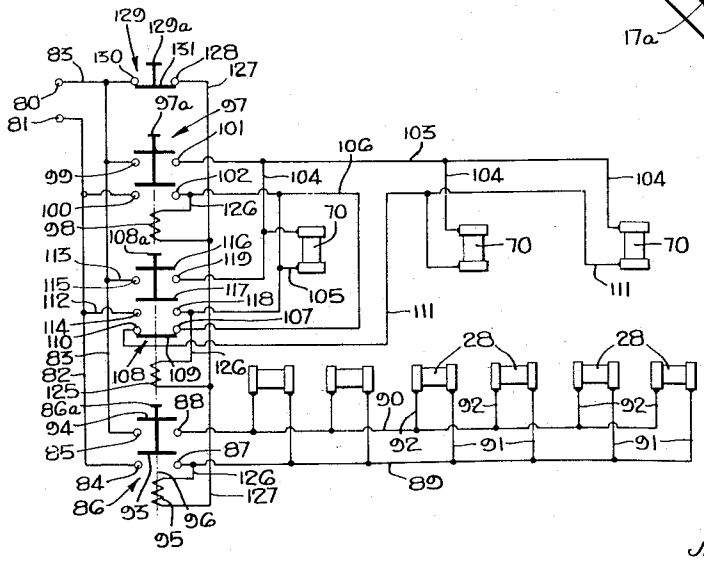

FIG. 20.

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United States Patent Office 2,719,043 Patented Sept. 27, 1955

2,719,043

MOVABLE SUPPORTING STRUCTURES

Jess Oppenheimer, West Los Angeles, Calif.

Application September 10, 1952, Serial No. 308,899

15 Claims. (Cl. 280—47.11)

The present invention relates to supporting structures for motion picture and television cameras, as well as for other equipment, and more particularly to structures that are movable along the ground or floor between various locations.

This application is a continuation-in-part of my application for "Caster," Serial No. 288,125, filed May 16, 1952, now Patent 2,687,546.

Heretofore, movable devices, such as camera trucks or dollies, have been restricted in their degree of mobility along a supporting surface, movement of the devices in certain desired ways being impossible of performance. In other situations, translation of the supporting structure between specified locations and along predetermined paths during operation of the device could be obtainable only in a difficult and inconvenient manner.

Accordingly, an object of the present invention is to provide improved supporting structures for devices, such as cameras, having a high degree of mobility.

Another object of the invention is to enable supporting structures for devices to have universal movement along the ground or floor under the control of the operator.

A further object of the invention is to enable structures for devices to be moved in all directions along a supporting surface, but in which the structures can still be moved or steered in particular directions under the operator's control.

Yet another object of the invention is to provide supporting structures for cameras and other equipment that are selectively movable in all directions over a surface, which can be steered in varying or straight-line paths, which can be caused to pivot about particular axes, and which can be held stationary.

A further object of the invention is to provide supporting structures for devices having ground engaging rollable members capable of universal movement, or of being caused to rotate about fixed axes.

Another object of the invention is to provide supporting structures for devices having ground engaging rollable members selectively controllable to permit universal movement of the members, or to cause rotation of one or more of the members about fixed axes. Under the latter condition, the one or more members may be steered in any direction.

Still another object of the invention is to provide supporting structures for devices which can be moved in any direction over a supporting surface, the direction of movement being abruptly changeable, if desired, and in which the structure can be steered in the manner of a wheeled vehicle.

Yet a further object of the invention is to provide supporting structures for devices capable of movement in all directions over a supporting surface, and of being steered in particular directions, all under the control of the operator and while he is operating the device.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of several forms in which it may be embodied. Such forms are shown in the drawings accompanying and forming part of the present specification. These forms will now be described in detail, illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

Figure 1 is a side elevation of one form of apparatus embodying the invention;

Fig. 2 is a vertical section, on an enlarged scale, taken along the line **2—2** on Fig. 1;

Fig. 3 is a cross-section taken along the line **3—3** on Fig. 2;

Fig. 4 is a diagrammatic view of the apparatus with the ground engaging elements arranged for movement in all directions;

Fig. 5 is a diagrammatic view of the apparatus, in which the rear ground engaging elements are locked to rotate about a single axis, and in which the front rollable element is steerable;

Fig. 6 is a diagrammatic view of the apparatus held in a stationary position;

Fig. 7 is a diagrammatic view of the apparatus with the parts arranged for pivoting of the entire device about one of the ground engaging members;

Fig. 8 is an enlarged section taken along the line **8—8** on Fig. 1;

Fig. 9 is an enlarged cross-section taken along the line **9—9** on Fig. 8;

Fig. 10 is a front elevational view, on an enlarged scale, of the control switches;

Fig. 11 is a vertical section, parts being shown in elevation, through another embodiment of a rollable ground engaging structure that can be incorporated in the apparatus shown in Fig. 1;

Fig. 12 is a vertical section taken along the line **12—12** on Fig. 11;

Fig. 13 is a side elevation of the control mechanism for the apparatus disclosed in Fig. 11;

Fig. 14 is an enlarged section taken along the line **14—14** on Fig. 13;

Fig. 15 is a side elevational view of still another embodiment of the invention;

Fig. 16 is a vertical section taken along the line **16—16** on Fig. 15;

Fig. 17 is a transverse view taken along the line **17—17** on Fig. 15;

Fig. 18 is a sectional view taken along the line **18—18** on Fig. 16;

Fig. 19 is a cross-section taken along the line **19—19** on Fig. 16;

Fig. 20 is a circuit diagram for controlling the apparatus illustrated in Figs. 1 to 10, inclusive.

In the form of invention disclosed in Figs. 1 to 9, inclusive, a motion picture camera **10**, or the like, is suitably mounted on the central upright portion **11** of a frame or support **12**, which is to be moved in various ways over a suitable supporting surface **13**, such as the ground or a studio floor. To facilitate such movement, the frame **12** is supported on the floor by a plurality of rollable members **14**, which are preferably in the form of balls or spheres rotatably carried within frame arms **15**, **15***a* fixed to the central upright **11**, and which may radiate from the axis of the latter. As disclosed, there frame arms **15**, **15***a* are provided spaced about 120 degrees apart.

Each ball **14** is made of a suitable material, such as steel, and may have an outer coating or covering **16** of rubber or rubber-like material. The ball is supported in a housing **17** or **18** carried by an arm **15**, its upper

portion bearing upon a row of ball bearing elements **19** rollable in a suitable race **20** formed in the arm housing. This row of balls **19** is prevented from dropping from its assembled position within the housing **17** or **18** by a suitable lower split retainer ring **21** carried within a companion groove **22** formed within the housing itself. It is evident that the floor engaging rollable element **14** bears against the upper row of ball bearing elements **19**. Dropping of the floor engaging element from the housing **17** or **18** is prevented by a lower split retainer ring **23** carried in a suitable circumferential groove **24** in the housing.

The ball arrangement just described is disclosed in Fig. 2 as applied to the front arm **15** of the supporting structure. A similar ball arrangement is disposed within the two rear arms **15***a* of the supporting structure **12**. As disclosed, the housing **17** of the front ball or caster member **14** is made rotatable or steerable, whereas, in the form of invention disclosed in Figs. 1 to 8, inclusive, the housings **18** for the rear rollable members **14** are fixed with respect to the supporting arm structure **18** of the apparatus.

The floor or ground engaging balls **14** enable the entire supporting structure, with the camera mounted thereon, to be moved over the supporting surface **13** in any direction. That is, a universal movement of each ball member is possible, whereby the supporting frame or structure **12** can be shifted in any direction, both along a straight-line path, a curved path, an irregular path, or the structure may be rotated about the vertical axis of the upright **11** and without any bodily translation taking place at all. Provision is made, however, for confining the rollable balls **14** for rotation about fixed axes whenever desired. As disclosed in the drawings, such fixed axes are preferably horizontally disposed.

As shown in Fig. 2, and perhaps to some extent more clearly in the form of invention illustrated in Fig. 16, a pair of diametrically opposed axle members **26** are rotatably carried within a pair of horizontally disposed cylindrical housing extensions **27** which radiate from the main portion of the ball housing **17, 18**. These axle or shaft members **26** may be brought into contact with the ball **14**, and, in effect, become coupled to the latter to confine it for rotation about a common or coaxial axis passing through both of the axle members **26**. When the axle members **26** are uncoupled, or released, from the ball, the latter can again partake of its universal movement.

As disclosed in the drawings (see Fig. 16), each cylindrical housing extension **27** has a solenoid coil **28** held therein, as by means of a split snap ring **29**. The axle member **26** is swivelly mounted within a solenoid plunger **30, 31**, the axle member **26** being rotatable within a hollow portion **32** of the plunger. The axis or end thrust between the axle **26** and the outer head portion of the plunger **31** is transmitted through a ball **33**, whereas the axle **26** is coupled to the plunger **30, 31** for axial movement therewith by a set of locking ball elements **34** disposed in a race **35** on the periphery of the axle shaft and within an internal circumferential groove or recess **36** in the plunger itself. The axle member **26** possesses an inner head **37** having a spherical surface that may have a spherically shaped lining **38** attached thereto for engagement with the surface of the floor engaging ball **14**.

Normally, the axle member **26** is urged in a direction out of engagement from the ball **14** by a helical spring **39** encompassing the plunger **30, 31**, the spring engaging a flange or seat **40** on the plunger and also the coil **28**. When current is caused to pass through the coil **28**, the plunger **30, 31** is urged inwardly thereof to contact the coupling facing **38** on the inner end of the axle with the sphere **14**, and thereby preclude universal movement of the sphere. In order to increase the magnetic force of the coil **28** on the plunger **30, 31**, the latter may be made with an outer portion **31** of magnetic material secured to an inner portion **30** of non-magnetic material, such as brass.

It is apparent that the simultaneous passage of current through the solenoid coils **28** on opposite sides of a sphere **14** will cause firm engagement of the axle members **26** with diametrically opposite sides of the sphere, and, since the axle members are disposed on a common horizontal axis, the sphere **14** and axle members **26** together with function in the manner of a wheel fixed to rotate about a particular axis, which, in this case, is the axis of the axle members themselves. Such rotation is permitted in view of the ball bearing lock **34** between each axle shaft **26** and the plunger **30, 31** and also because of the thrust ball bearing element **33** between the end of the axle and the plunger.

The structure shown in Fig. 1 provides for the steering of the front or forward spherical member **14**. However, the rear two spherical members are non-steerable in this embodiment of the invention. It is preferred that the solenoid coils **28** for these rear two members be disposed at right angles to a central vertical plane **42** through the vertical axis **43** of the apparatus and the vertical axis through the center of the forward sphere (Fig. 5). In this manner, the apparatus may be caused to assume the characteristics of a three-wheeled vehicle when the solenoids **28** for all of the spheres **14** are energized. The energizing of the rear solenoids will lock the two rear ball members **14** for rotation about a common horizontal axis **44**. Since the front ball member is made steerable in the manner hereinafter described, the energizing of all of the solenoids **28**, coupled with the steering of the front member, enables the entire structure to be moved over the ground or floor **13** in the manner of a three-wheeled vehicle having a front end steering mechanism.

The housing **17** for the front spherical member **14** and solenoids **28** is rotatable about a vertical axis. This housing is provided with an upper spindle **45** rotatably mounted in the forward fixed arm **15**. A suitable anti-friction bearing **46** is provided between the housing **17** and the arm **15** to facilitate relative rotation between the two, this friction bearing being capable of transmitting both axial and radial thrust between the members. As disclosed, a lower race **47** bears upon a shoulder **48** of the rotatable housing **17**, this race receiving a set of ball bearing elements **49** that fit within an opposed upper race **50** carried within the fixed arm **15** and bearing against a shoulder **51** in the latter. In this manner, the load of the fixed arm **15** is borne by the rotatable housing **17**, and through the ball bearings **19** in the latter this load is transmitted to the main sphere **14**, which is engaging the ground **13**. Axial separating movement between the rotatable housing **17** and arm **15** is prevented by positioning a split retainer ring **52** in a groove **53** in the upper portion of the spindle **45** and causing this retainer ring to engage the shoulder or base **54** of a counterbore **55** provided in the upper portion of the fixed arm.

The entire forward cylindrical housing member **17** may be rotated about the vertical axis passing through the center of the front sphere **14** by any suitable mechanism. As disclosed in the drawings, a worm wheel **56** is secured, as by means of a key **57**, to the spindle **45**, and this wheel meshes with a worm **58** rotatably carried between ball bearings **59** fixedly mounted in the arm **15** itself (Fig. 3). A shaft **60** is integral with, or otherwise suitably secured to, the worm **58** and is attached to a flexible shaft **61** located within a flexible shaft housing **62** extending through the frame or support **12** and into a tubular operating arm **63** attached to the camera mounting **10**, and by means of which the cameraman can manipulate the camera itself. Within the operating arm **63**, the flexible shaft **61** is attached to the inner end of a shaft **64** piloted within the tubular operating arm (Fig. 8). This shaft is attached to an outer handle **65** rotatable on the periphery of the operating arm **63**, the handle being prevented from moving axially by means of a suitable screw

66 threaded therein and received within a peripheral groove 67 in the operating arm. This handle may have a rubber, cork, or other suitable coating 68 thereon to facilitate its gripping by the cameraman.

By grasping the handle 65 and rotating it in one direction or the other, the rotary motion is transmitted through the flexible shaft 61 to the worm 58, and from the worm to the worm wheel 56, for the purpose of rotating the forward housing 17 about the vertical axis passing through the center of the front sphere 14. With the horizontally disposed solenoids 28 energized and their companion axle members 26 coupled to the sphere 14, the latter will function as a wheel. Upon rotation of the forward housing 17 through rotation of the worm 58 and worm wheel 56, the direction of the forward sphere 14 can be changed. Assuming that the rear solenoids 28 have also been energized, to cause the rear spheres 14 to function in the manner of wheels having trunnions 26 extending therefrom, then the energizing of the forward solenoids 28 converts the vehicle into a three-wheeled mechanism, with the front wheel steerable, so as to control the direction in which the vehicle will move.

In the event it is desired to prevent rolling movement of any of the main spheres 14 along the supporting floor or ground 13, an upper solenoid 70 is actuated to move a vertically arranged axle member 71 downwardly into engagement with the sphere, the axis of the vertically arranged axle member 71 passing through the center of the sphere 14. The vertically arranged solenoid coil 70, its axle member 71, plunger 72, spring device 73 and friction facing and liner 74 may be identical with the axle member arrangement 26—38 for engaging the sphere and disposed along the horizontal axis.

As disclosed in Fig. 2, it is evident that the energizing of the upper vertical solenoid coil 70 of any one of the spheres 14 will cause the axle member 71 to engage its upper end and preclude rolling of the sphere in any direction. However, the supporting structure 12 itself is not precluded from being pivoted about the vertical axis of the axle member 71 passing through the center of the sphere. If more than one of the vertically arranged solenoids 71 is energized, then the apparatus will be held in a stationary position, in view of the inability of two of the spheres 14 to roll along the floor surface 13. Of course, if all three of the vertically arranged coils 70 are energized, then the vehicle will also be maintained in a stationary position.

By means of the apparatus disclosed and described, the camera supporting mechanism 12 can be moved in practically any direction, and at the will of the operator. Examples of the operation of the apparatus are shown diagrammatically in Figs. 4, 5, 6 and 7. In Fig. 4, all of the solenoids 28 and 70 for all spheres 14 are deenergized, so that none of the axle members 26, 71 engage any of the spheres. Under this condition, each of the spheres 14 is a free rolling member, permitting rolling movement of the entire structure over the supporting surface 13 in any direction. That is, each sphere 14 is capable of partaking of free universal movement along the supporting surface.

In Fig. 5, the vertically disposed solenoids 70 remain deenergized, but all of the horizontal solenoids 28 have been energized to engage the axle members 26 with all spheres 14. As shown in Fig. 5, the rear spheres 14 and rear axle members 26 together will constitute two rear wheels rotatable about a common horizontal axis 44, whereas the front or forward sphere 14 and axle members 26 will constitute a front wheel rotatable about a horizontal axis, which axis, however, is shiftable, since the handle 65 on the lever arm 63 can be manipulated in either direction, operating through the flexible cable 61, worm 58 and worm wheel 56 to turn the entire rotatable caster housing 17 about a vertical axis passing through the center of the front sphere 14. In the full line position shown in Fig. 5, the vehicle is moved straight ahead with all of the axle members 26 rotatable about parallel axes. Rotation of the worm 58 and worm wheel 56 can shift the horizontal axis of the front sphere 14 and its axles 26 to different angular positions, so as to cause the front sphere to move in different directions and cause the vehicle to travel along a curved path, in the manner of a three-wheeled vehicle.

As shown in Fig. 6, all of the vertical solenoids 70 have been energized, which precludes rotation of the spheres 14 in any direction, thereby holding the entire vehicle in a stationary position. Of course, if the horizontally disposed solenoids 28 are deenergized at this time, the spheres 14 could theoretically move about vertical axes passing through their centers, but such motion would not be associated with movement of the supporting structure or frame 12 itself.

In Fig. 7, the horizontal solenoids 28 have all been deenergized, and only one of the vertical solenoids 70, such as the one for the front sphere 14, has been energized, to preclude rotation of the forward sphere relatively with respect to its housing 17 except about a vertical axis passing through its center. The rear spheres 14 can then partake of universal movement, but the front sphere cannot move. Under this condition, the entire vehicle can be pivoted about a vertical axis passing through the center of the front sphere. Of course, either of the other vertical solenoids 70 could be energized alone, and the pivoting would then take place about a vertical line passing through the center of that particular sphere.

In Fig. 20, a wiring diagram is disclosed for controlling the various solenoids 28, 70 in the manners just described. Current is derived from a suitable power supply 80, 81, and can pass through both the vertical locking solenoids 70 and the horizontal axle solenoids 28. The power supply lines are connected through suitable leads 82, 83 to a pair of contacts 84, 85 forming part of a switch 86 for the horizontal solenoids 28, the switch including another pair of contacts 87, 88 connected to conductive lines 89, 90 across which each horizontal solenoid 28 is connected through suitable leads 91, 92. The contacts 85, 88 and 84, 87 may be bridged by the poles 93, 94 of the switch 86, which is of the type that may have a spring (not shown) normally tending to move the poles out of engagement from the contacts. However, when the double pole switch pieces 93, 94 move into engagement with the contacts 85, 88 and 84, 87, it is held in such engagement by current passing through a holding solenoid coil 95 which attracts a plunger 96 secured to the elements 93, 94. The opening of the circuit to this holding coil 95 then allows the spring (not shown) to move the switch 86 to a position opening the circuit to the axle solenoids 28.

Through manipulation of a suitable switch 97, the current to the vertical solenoids 70 can be controlled. This switch is the same as the switch just described, also containing a holding solenoid 98. One set of contacts 99, 100 of the switch is connected to the power supply lines 82, 83, the other pair of contacts 101, 102 being connected to the vertically disposed solenoids 70. As shown in Fig. 20, a line 103 from contact 101 is connected to a lead 104 running to one end of each solenoid 70, the other end of the solenoid coil 70 for the front sphere 14 being connected to a lead 105 running to another line 106 connected to the switch contact 102. This other line 106, however, does not extend directly to the vertical solenoids 70 for the rear spheres 14. Instead, it passes to a contact 107 of a switch 108 for controlling the pivoting of the apparatus depicted diagrammatically in Fig. 7, a pole 109 of this switch being engageable with this contact 107 and also with another contact 110 connected to a lead 111, which is, in turn, connected to the other end of each rear vertical solenoid 70.

The switch arm or bridging portion 109 just described is secured to and forms part of a switching device 108, which is capable of controlling the passage of current to

the front vertical solenoid 70 alone. The power supply lines 82, 83 are connected by suitable leads 112, 113 to a pair of contacts 114, 115, a double pole switch member 116, 117 being engageable with these contacts and also with another pair of contacts 118, 119 connected to electric lines 105, 104 running to opposite ends of the front brake solenoid coil 70. The switch 108 just described is normally urged to a disengaged position by means of a suitable spring (not shown), in which disengaged position it connects the lead 106 running from the locking switch 97 and to the front brake solenoid 70 to the rear brake solenoids 70 through the line 111. However, when the switch members 116, 117 are depressed, then this circuit 106, 107, 110, 111 to the rear brake solenoids 70 is interrupted, and only the circuit to the front brake solenoid 70 can be completed. As with the other switches, the pivot switch 108 is also held in closed position by means of a solenoid coil 125.

The aforenoted holding coils 95, 98, 125, to maintain the three switches 86, 97, 108 in closed positions, derive their current from the power supply 80, 81, the current being permitted to pass through each holding coil whenever its associated switch is closed. Thus, one end of each solenoid coil is connected to a line 126 leading from each switch on its outlet side, the other end of each coil being connected to a line 127 running to a contact 128 of a single pole switch 129 having another contact 130 connected to the other line 83 of the power supply, the contacts being bridged by a pole piece 131. Whenever the single pole switch 129 is opened, then the circuits to all of the holding solenoids 95, 98, 125 are interrupted and the springs associated with these particular switches shifts them back to open position, and, in the case of the pivot switch 108, moves its lowermost bridging member 109 to a closed position with respect to the circuit 106, 111 running to the rear brake solenoid 70. The off switch 129 also has a spring (not shown) that normally holds it in closed position.

The four buttons or plungers 129*a*, 97*a*, 108*a*, 86*a* for the four switches 129, 97, 108, 86 are conveniently located within easy reach of the cameraman. Thus, as shown most clearly in Fig. 10, the top button 129*a* controls the off switch 129 for the holding solenoids 98, 125, 95, the next button 97*a* operating the locking switch 97 for controlling passage of current through all of the vertical solenoids 70, the third button 108*a* in descending order operating the pivot switch 108 for causing current to pass through the front vertical solenoid 70 only, and precluding current from passing through the other two rear solenoids 70; whereas the bottom button 86*a* operates the switch 86 for causing current to pass through all of the horizontal solenoids 28, for the purpose of converting the spheres 14 into wheel-like members.

Assuming that the off switch 129 is depressed, all of the holding solenoids 98, 125, 95 are deenergized, the other switches shifting to the positions disclosed in Fig. 20, in which the lower member 109 of the pivot switch 108 bridges the lowermost contacts 107, 110. Under this condition of operation, no current is passing through any of the solenoids 28, 70 and the vehicle is in the free rolling, non-directional position, in which all of the spherical floor engaging members 14 can rotate in any direction, such as shown in Fig. 4. In the event it is desired to convert the spheres 14 into wheel-like members, then the roll switch button 86*a* is pushed inwardly to close the roll switch 86, causing current to pass through all of the horizontal solenoids 28, whereupon the vehicle is in the position depicted in Fig. 5. In the event it is desired to hold the vehicle stationary, then the off switch 129 may be manipulated to deenergize the holding solenoid 95 for the roll switch 86, which deenergizes all of the horizontal solenoids 28, whereupon the lock switch 97 may be closed, which will cause current to pass through all of the vertical solenoids 70, in order to hold all of the spheres 14 from rotating, thus securing the vehicle in a stationary position. This condition is illustrated in Fig. 6. In the event it is desired to pivot the vehicle about a vertical line passing through the axis of the forward or front sphere 14, then the off switch 129 is again depressed to deenergize the holding solenoid for the lock switch 97, and the pivot switch button 108*a* depressed, which then completes the circuit to the vertical solenoid 70 for the front member 14 only, precluding rotation of the front sphere and allowing the entire apparatus to be swung about the vertical axis passing through the center of this sphere.

In the embodiment of invention disclosed in Figs. 11 to 14, inclusive, mechanical means are shown for controlling one of thhe spherical ground engaging elements 14, instead of the electrical devices heretofore described. This particular mechanical arrangement may be used for the rear spherical members, in place of the solenoids now disclosed.

In Figs. 11 to 14, each frame arm 150 contains the recess 151 for the ground engaging member 14, as well as the supporting bearings 19 for minimizing friction. The ball 14 may be prevented from rolling along the floor or ground surface 13 by a vertical member including the stub axle 152 having a friction facing 153 thereon, which is rotatable within a piston member 154 through the agency of retaining balls 155 and a central thrust ball member 156, the axis of rotation being vertical and passing through the center of the sphere 14. The piston member 154 itself is reciprocable within a suitable vertical socket 157 in the arm 150, and is urged in a downward direction by a helical compression spring 158 bearing upon its upper end and against the upper end of the socket 157.

The ability of the spring 158 to so engage the friction facing 153 of the stub axle 152 with the upper portion of the sphere 14 depends upon the position of a longitudinally movable tapered, or cam, member 159, which extends through a vertically elongated slot 160 in the piston member 154. This slot 160 has a tapered surface 161 engageable with a companion tapered surface 162 on the longitudinally movable cam member 159, the cam member itself being reciprocable within a horizontal bore 163 provided in the arm 150.

The cam member 159 is attached to a flexible actuated rod 164 disposed within a flexible housing 165 suitably secured to a bracket 166 attached by screws 167 to the fixed arm 150. This actuating rod 164 is attached to a plunger 168 slidable within a guide tube 169 in a housing member or box 170 mounted on the frame or support 12 adjacent the operator. The plunger 168 is guided in its movement by a pin 171 slidable within a slot 172 in the guide tube 169.

Inward movement of the plunger 168 shifts the cam shaft 159 to the left, as seen in Fig. 11, which allows the compressed spring 158 to engage the stub axle 152 with the sphere 14, thereby precluding its rolling movement along the ground or floor surface 13. Movement of the plunger 168 in an outward direction will shift the cam rod 159 in the opposite direction, causing its cam surface 162 to engage the companion cam surface 161 on the piston 154 and raise the piston, shifting the stub axle 152 out of engagement from the sphere 14, against the force of the spring 158. The cam member 159 will remain in this position, since the angle of taper 162 of the cam is a self-locking angle.

By means of a similar construction, a pair of diametrically opposed and horizontal stub axle members 175 have their friction facings 176 engageable with the surface of the sphere 14 and these members 175 are also rotatable within horizontally disposed piston members 177 reciprocable in bores 178 in the cylindrical housing extensions 179. Compressed helical springs 180 urge the piston members 177 inwardly toward the center of the sphere 14, to engage the friction facings 176 of the stub axles with the surface of the sphere. Reciprocable cam

members **181** and their associated actuating rods **182** are provided for effecting engagement or disengagement of the stub axles **175** with the spheres **14**, these actuating rods **182** running to plungers **183** located at essentially the same position as the plunger **168** for the vertical cam **159** and stub axle member **152**.

It is evident that actuation of the plungers **168**, **183** to release all of the stub axle members **154**, **175** from the sphere **14** will permit the latter to partake of universal movement. Actuation of the rods **182** for the horizontal piston members **177** and stub axles **175** in the proper direction, to cause the springs **180** to engage the stub axles **175** with the sphere **14** will place the rear sphere members in the same position as depicted in Fig. 5, in which they are converted into wheel-like members. Similarly, actuation of the other rod **164** in the proper direction will allow the vertical piston member **154** to move downwardly and shift the vertical stub axle **152** into engagement with the sphere **14**, inhibiting rolling of the sphere **14** along the ground surface **13**.

In the form of invention shown in Figs. 1 to 10, inclusive, only one of the floor contacting spheres, such as the front sphere **14**, is made steerable when the horizontal solenoids **28** are energized, to cause the sphere to rotate about a horizontal axis. In the embodiment of the invention illustrated in Figs. 15 to 19, inclusive, all of the floor contacting spherical elements **14** may be made steerable, either selectively or simultaneously.

The camera supporting frame **12***a* is essentially the same as disclosed in Fig. 1. This frame has the central upright or pedestal portion **11** from which radiate three arms **200**. The housing **17***a* for each of the spherical ball members **14** is made rotatable, in substantially the same manner as disclosed in Fig. 2. Of course, each rotatable housing includes the horizontal and vertical solenoids **70**, **28** which can be energized through controlling the electric circuits thereto. Each housing spindle **45***a* extends upwardly above its arm **200** for the reception of a sprocket **201** rotatable upon an upper reduced diameter spindle portion **202** and bearing upon a transverse spindle shoulder **203**. The sprocket **201** is retained in appropriate position on the spindle by a split retainer ring **204** received within a peripheral groove **205** in the spindle and overlapping the sprocket.

Each sprocket **201** is freely rotatable on the spindle **45***a*, but can be clutched thereto so that rotation of the sprocket will cause corresponding rotation of the spindle **45***a* and the housing **17***a* attached thereto. As shown in the drawings, the lower surface of the sprocket **201** is provided with a vertical clutch recess **206** capable of receiving a clutch and brake tooth or dog **207** vertically reciprocable along the spindle. This clutch dog **207** may constitute the splunger of a solenoid, being reciprocable within a solenoid coil **208** suitably secured to the spindle **45***a*, as by means of an encompassing band or bracket **209** attached to the spindle by the screws **210** (Fig. 19). A helical compression spring **211** is disposed within the solenoid coil **208**, with its upper end bearing upon a portion of the coil frame **208**, and its lower portion bearing upon a dog flange **212** tending to urge the dog **207** in a downward direction, completely out of the clutch recess **206**. When the solenoid **208** is energized, the clutch dog **207** is elevated against the force of the spring **211**, the upper clutch portion **207***a* of the dog being capable of entering the clutch recess **206**, which is substantially the same width as the clutch dog itself, thereby coupling the sprocket **201** to the spindle **45***a*.

The spindle **45***a* may also be secured against rotation by detachably securing it to the radial arm **200**. Thus, the radial arm may have a plurality of circumferentially spaced brake recesses **215** into which the lower or brake portion **207***b* of the dog **207** may fit, for the purpose of coupling the spindle **45***a* to the radial arm **200**. The arrangement is such that the spring **211** will cause the lower portion **207***b* of the dog **207** to enter one of the recesses **215** when the solenoid **208** is deenergized, whereas energization of the solenoid coil will elevate the dog to remove its brake portion **207***b* from one of the arm recesses **215** and urge its clutch portion **207***a* into a position within the clutch recess **206** in the sprocket **201**.

The clutch and brake dog **207** is preferably appropriately oriented with respect to the common axis through the horizontal solenoid coils **28** in each housing **17***a*. As disclosed, a vertical plane passing through the horizontal solenoid axis will pass through the vertical center line of the dog **207**. As a result, when the solenoid **208** is energized and the clutch dog **207** enters the recess **206** in the sprocket **201**, the latter will occupy a definite position with respect to the common axis of the horizontal solenoid members **28**.

Since the fixed radial arms **200** are three in number, displaced 120 degrees apart, each arm has three brake recesses **215** that are also disposed 120 degrees apart. One recess **215** in each of the rear brake arms **200** will lie on vertical planes passing through the centers of a pair of spheres, such as the plane P—P passing through the centers of the nominally rear spheres **14**, as illustrated diagrammatically in Fig. 17. The front arm **200** will have a recess **215** lying in a vertical plane P^1P^1 passing through the center of its sphere and parallel to the plane P—P.

Each arm **200** will have another brake recess **215** displaced 120 degrees from the recess just mentioned, and lying in vertical planes S—S, which pass through the centers of another pair of spheres, such as the right sphere and the front sphere, a vertical plane S—S parallel to the one just mentioned and passing through the center of the left rear sphere also locating a brake recess for the left rear arm. In a similar fashion, a third recess is provided in each arm **200** lying in a plane R—R passing through the centers of the front and left rear spheres, a corresponding recess lying in a plane R—R parallel to the one just mentioned and passing through the center of the right rear sphere **14** within the right rear radial arm **200**.

The brake recesses **215** in each arm **200** are thereby located 120 degrees apart, so as to orient the common axis of the solenoid members **28** and the stub axles **26** for each sphere positively in either of three directions with respect to the arm **20**. Thus, the axes for all of the spheres can be oriented to lie in the vertical planes P—P, or R—R, or S—S, as shown diagrammatically in Fig. 17. It is unnecessary that all of the axes be so oriented at the same time, although this can occur, when desired, by deenergizing the clutch and brake dog solenoids **208** for all three members. Another mode of use includes the deenergization of the front and one rear solenoid **208**, their associated spindles **45***a* being turned about their respective vertical axes to place each brake member **207** in a position which will lock the front and a rear spindle **45***a* to the radial arms **200** along a particular plane, the other spindle solenoid **208** being energized to withdraw the dog **207** from engagement with the fixed arm **200**, allowing its companion spindle **45***a* to be rotated by rotating the sprocket **201**, which becomes clutched to the dog **207** and the spindle **45***a* itself. This latter spindle **45***a* could then be steered by turning the sprocket **201** coupled to it.

Each spindle **45***a* may be rotated, in order to place its dog **207** in alignment with one of the brake recesses **215**, and also with the clutch recess **206** in the sprocket **201**, by any suitable means. As disclosed in the drawings, a hand lever **250** is secured to the upper portion of each spindle **45***a*, the lever being retained in position by a suitable washer **251** and a screw **252**. The grasping of the hand lever **250** will enable the spindle **45***a* and its housing **17***a* to be rotated, for the purpose of appropriately locating the dog **207** in alignment with the desired brake recess **215**, or in alignment with the clutch recess **206**, when the solenoid **208** is energized. In the event the clutch recess **206** is not aligned with the dog **207**, it may not be necessary to rotate the spindle **45***a* at all. Instead, the energizing of the solenoid **208** will cause the dog **207** to

bear against the underside of the sprocket **201** until the latter has been rotated into a position in which its recess **206** is aligned with the dog, whereupon the latter will snap into the recess, to couple the sprocket **201** to the spindle **45***a*.

When all of the clutch dogs **207** are engaged in the clutch recesses **206** in the sprockets **201**, then each sprocket occupies a particular position with respect to the horizontal axis through the stub axles **26**. Since the dog **207** lies in the vertical plane passing through this axis, each clutch recess **206** will also lie in this same vertical plane when the dog is received therewithin. Accordingly, when all of the dogs **207** are received within the sprocket recesses **206**, all of the sprocket recesses lie in vertical planes that are parallel to each other. This parallel relationship may be maintained by suitably interconnecting all of the sprockets **201**, as by passing an endless chain **260** therearound. The chain may be moved linearly to rotate the sprockets **201** in any suitable manner, as by means of a steering wheel **261** attached to a vertical shaft **262** rotatable in a suitable bracket **263** secured to the upright portion **11** of the frame, and having a sprocket **264** at its lower end engaging the chain. Rotation of the steering wheel **261** will cause all of the sprockets **201** to move simultaneously, and, since the clutch recesses **206** in the sprockets have been initially oriented to lie in vertical planes parallel to one another, such orientation will always be maintained.

Accordingly, in the event that all of the solenoids **208** have been energized and the dogs **207** located in the clutch recesses **206**, then the axes of the horizontal stub shafts **26** will all be parallel to each other. Accordingly, turning of the steering wheel **261** will cause corresponding turning of all of the spindles **45***a* and housings **17***a* to the same extent, which enables all of the housings to be steered simultaneously and caused to maintain their same relative direction.

With all of the dogs **207** engaged in the sprocket clutch recesses **206**, the frame **12***a* of the apparatus can be moved along straight line paths in any direction, with the horizontal solenoid coils **28** all energized. Again, any pair of housings **17***a* can be locked in a particular position to their respective frame arms **209** and only one of the spindles **45***a* and housings **17***a* steered through rotation of the steering wheel **261**, shaft **262**, chain **260** and sprocket **201**. As an example, if it is desired to lock the normal front and left rear housings **17***a* to the frame **12***a* and steer the right rear housing only, then the front and left rear clutch solenoids **208** will be deenergized, the spindles **45***a* being turned until the drop **207** for the front and left rear spindles lie on the plane R—R, whereupon the dogs will fall in the appropriate locking recesses **215** in the arms **209**. The housings **17***a* for the front and left rear members are thereby prevented from turning, the axis of the horizontal axle solenoids **28** lying in the vertical plane R—R (Fig. 17). The solenoid **208** for the right rear spindle can remain energized, whereupon the turning of the steering wheel **261** will be effective only to steer the right rear housing **17***a*, causing movement of the frame **12***a* in the same manner as is depicted diagrammatically in Fig. 5 of the other embodiment of the invention.

It is, accordingly, apparent that by appropriately controlling the various spindles **45***a* and the dog solenoids **208**, either one of the rotatable housings **17***a* may become a steering member and the balls **14** of the other two members may become fixed axis wheel-like members, thereby enabling either one of the spherical members to act as a steering device. Of course, all of the members can be steered simultaneously, as explained above.

The apparatus disclosed in Figs. 15 to 19, inclusive, can also be operated in the same manner as the apparatus shown in Figs. 1 to 10, inclusive, by appropriately controlling the circuits through the horizontal solenoid coils **28** and the vertical solenoid coils **70**, to manipulate the apparatus in any of the manners depicted diagramatically in Figs. 4, 5, 6 and 7.

It is, accordingly, apparent that movable supporting structures for cameras and corresponding apparatus have been provided that have a great degree of freedom of movement, all under the selective control of the operator. As a result, the operator can position his camera at any selected point and he can also move the camera in any desired manner. The camera can be held stationary, it can be pivoted about its own axis merely by rotating the entire support about the axis of the upright **11**, it can be caused to pursue a straight-line path, can be turned around corners in an exceedingly short radius, it may be tilted, or it may be held completely stationary. In addition, any one of the members can be used as a steering member to abruptly change the direction in which the camera support will move.

The inventor claims:

1. In mobile apparatus: a supporting structure; a plurality of floor engaging generally spherically shaped members on said structure capable of universal movement; means releasably engageable with said members to restrain their universal movement; means for selectively operating said engaging means to determine which of said members will have its rotation restrained; and means for steering at least one of said members for angular movement about a generally vertical axis.

2. In mobile apparatus: a supporting structure; a plurality of floor engaging generally spherically shaped members on said structure capable of universal movement; means releasably engageable with said members to confine them for rotation about generally horizontal axes; means for selectively operating said engageable means to determine which of said members will have its rotation confined; and means for steering at least one of said members for angular movement about a generally vertical axis.

3. In mobile apparatus: a supporting structure; a plurality of floor engaging generally spherically shaped members on said structure capable of universal movement; means releasably engageable with one of said members to confine it for rotation about a generally horizontal axis; and means for steering said one of said members about a generally vertical axis when said releasable means is engaged with said one of said members.

4. In mobile apparatus: a supporting structure; a plurality of floor engaging generally spherically shaped members on said structure capable of universal movement; means supporting one of said members and swivelly mounted on said structure; means on said supporting means releasably engageable with said one of said members to confine it for rotation about a generally horizontal axis; and means for turning said supporting means with respect to said structure to transfer the position of said horizontal axis angularly with respect to said supporting structure.

5. In mobile apparatus: a supporting structure; a plurality of floor engaging generally spherically shaped members on said structure capable of universal movement; means supporting one of said members and swivelly mounted on said structure; means on said supporting means releasably engageable with said one of said members to confine it for rotation about a generally horizontal axis; means for turning said supporting means with respect to said structure to transfer the position of said horizontal axis angularly with respect to said supporting structure; and means for releasably securing said supporting means against turning movement relative to said structure.

6. In mobile apparatus: a supporting structure; a plurality of floor engaging generally spherically shaped members on said structure capable of universal movement; means supporting one of said members and swivelly mounted on said structure; means on said supporting means releasably engageable with said one of said members to confine it for rotation about a generally horizontal axis; means for turning said supporting means with respect to said structure to transfer the position of said horizontal axis angularly with respect to said supporting structure;

and means releasably engageable with said other members for confining them for rotation about a common generally horizontal axis.

7. In mobile apparatus: a supporting structure; a plurality of supporting means individually swivelly mounted on said structure; a floor engaging generally spherically shaped member carried by each supporting means and capable of universal movement; means on each supporting means releasably engageable with the member carried thereby to confine such member for rotation about a generally horizontal axis; and means for turning all of said supporting means with respect to said supporting structure to transfer angularly the positions of the horizontal axes of rotation of said members with respect to said supporting structure.

8. In mobile apparatus: a supporting structure; a plurality of supporting means individually swivelly mounted on said structure; a floor engaging generally spherically shaped member carried by each supporting means and capable of universal movement; means on each supporting means releasably engageable with the member carried thereby to confine such member for rotation about a generally horizontal axis; means for turning all of said supporting means with respect to said supporting structure to transfer angularly the positions of the horizontal axes of rotation of said members with respect to said supporting structure; and means for releasably securing each of said supporting means in a particular position with respect to said structure.

9. In mobile apparatus: a supporting structure; a plurality of supporting means individually swivelly mounted on said structure; a floor engaging generally spherically shaped member carried by each supporting means and capable of universal movement; means on each supporting means releasably engageable with the member carried thereby to confine such member for rotation about a generally horizontal axis; and means interconnecting said supporting means for simultaneously turning all of said supporting means with respect to said structure to transfer angularly the positions of the horizontal axes of rotation of said members with respect to said structure while maintaining said horizontal axes substantially parallel to each other.

10. In mobile apparatus: a supporting structure; three floor engaging spherically shaped members on said structure capable of universal movement with respect to said structure, said members being angularly displaced around the structure with respect to each other; means engageable with two of said members to confine them for rotation about a common generally horizontal axis; another means engageable with the remaining member to confine it for rotation about a generally horizontal axis; and means for steering said remaining member when said another means is engaged therewith.

11. In mobile apparatus: a supporting structure; three floor engaging spherically shaped members on said structure capable of universal movement with respect to said structure, said members being angularly displaced around the structure with respect to each other; means engageable with two of said members to confine them for rotation about a common generally horizontal axis; means supporting said remaining member and swivelly mounted on said structure; another means on said supporting means engageable with said remaining member to confine it for rotation about a generally horizontal axis; and means for turning said supporting means with respect to said structure to transfer the position of the horizontal axis of rotation of said remaining member with respect to said supporting structure.

12. In mobile apparatus: a supporting structure; three supporting means individually swivelly mounted on said structure, said three means being angularly displaced around the structure with respect to each other; a floor engaging generally spherically shaped member carried by each supporting means and capable of universal movement with respect to said supporting means; means on each supporting means releasably engageable with the member carried thereby to confine such member for rotation about a generally horizontal axis; and means interconnecting all of said supporting means for turning all of said supporting means with respect to said structure to transfer angularly the positions of said horizontal axes of rotation of said members with respect to said structure.

13. In mobile apparatus: a supporting structure; three supporting means individually swivelly mounted on said structure, said three means being angularly displaced around the structure with respect to each other; a floor engaging generally spherically shaped member carried by each supporting means and capable of universal movement with respect to said supporting means; means on each supporting means releasably engageable with the member carried thereby to confine such member for rotation about a generally horizontal axis; means interconnecting all of said supporting means for turning all of said supporting means with respect to said structure to transfer angularly the positions of said horizontal axes of rotation of said members with respect to said structure; and means for selectively securing any two of said supporting means to said structure in positions placing the horizontal rotational axes of the members carried by said two supporting means in coincidence with each other.

14. In mobile apparatus: a supporting structure; a plurality of floor engaging generally spherically shaped members on said structure capable of universal movement; first means releasably engageable with one of said members to confine it for rotation about a generally horizontal axis; second means releasably engageable with said one of said members to preclude its rotation about a non-vertical axis; and means for steering said one of said members for angular movement about a generally vertical axis when said first means is engaged with said one of said members and said second means is released from said one of said members.

15. In mobile apparatus: a supporting structure; a plurality of floor engaging generally spherically shaped members on said structure capable of universal movement; means supporting one of said members and swivelly mounted on said structure; means on said supporting means releasably engageable with said one of said members to confine it for rotation about a generally horizontal axis; means for turning said supporting means with respect to said structure to transfer the position of said horizontal axis angularly with respect to said supporting structure; means releasably engageable with said other members for confining them for rotation about a common generally horizontal axis; and means releasably engageable with each of said members to preclude its rotation about a non-vertical axis.

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