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## (54) SUPPORT STRUCTURE


(71) We, GARRETT WOOD BROWN, a citizen of the United States of America, of 508 Pine Street, Philadelphia, Pennsylvania 19106, United States of America, and ARNOLD DIGIULIO, a citizen of the United States of America, of 2037 Granville Avenue, Los Angeles, California 90025, United States of America, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:–


This invention relates to a support structure for movably mounting a portable device on a movable carrier having particular but not exclusive application to supporting a motion picture or television camera on an ambulatory cameraman.

In taking photographs with a strip film fed motion picture camera or when employing a television camera, it is extremely important that the camera be maintained in as stable a position as possible in order to obtain high quality results. Such stability commonly has been achieved by mounting the camera on a tripod or otherwise supporting the camera, either a television or motion picture type, on a stationary support so as to eliminate any possibility of the undesireable camera motion. Problems generally arise when it is desired to take motion pictures under conditions wherein it is necessary or desirable that the camera itself be mobile or be moved during the photographic process. In such procedures, it has been the usual prior art practice generally to mount the camera on a wheeled dolly, sometimes running on temporary tracks or on a constructed platform extending along the intended path of movement, thereby permitting the camera equipment to be moved along a smooth path. When it has been necessary or desirable to employ a hand-held camera, high quality results have generally been unobtainable when the cameraman walks or runs with the camera because of the attendant increase in instability, particularly the quick angular deviations along the axes of pan, tilt and roll, which cannot be adequately controlled. Such instability has heretofore been characteristic of hand-held motion picture photography.

In order to overcome the problems encountered in hand-held cimematography and to reduce the great expense normally encountered in construction of temporary tracks or temporary platforms, prior workers in the art have attempted to develop portable camera stabilizing devices. One such device has been disclosed in the United States Patent No. 2 945 428. It was found that the camera had little or no mobility relative to the cameraman which tends to limit the versatility of camera angles or types of shots which can be made with the device. Furthermore, the cameraman's body is in contact with the camera, and his motions are directly transmitted to the camera resulting in jitter. Other prior workers in the art have attempted to solve the problem by employing gyro stabilizers and lens constructions which adjust the light paths entering the camera in order to produce a stabilized image. These devices also require that the camera be mounted in a relatively fixed position with respect to the cameraman. These prior art devices tend to restrict the speed of panning and tilting that can be achieved and are further deficient in that they introduce other arbitrary motions of their own if their inherent limits are exceeded by walking or running. Further, the prior art devices insofar as is known without exception, are of little benefit to translational stability or motion about the axis passing through the camera's lens. All of these prior art stabilizing devices require the addition of considerable weight beyond that of the camera itself thereby introducing a factor directly relating to the strength of the cameraman himself. The foregoing factors tend to limit the versatility of these prior art devices by limiting the camera angles and the type of shots which can be achieved by utilizing such equipment.

None of these prior art devices has been completely successful because of the lack of one or more of the following requirements:

1. inherent stability, that is, the tendency to resist the rapid angular motions around all three possible axes that plague hand-held shooting, and slow them down to the point that the human body can effectively deal with without introducing new ones;

2. floatation and isolation, that is relieving the cameraman of the necessity to exert force to support the camera, thus preserving the delicacy of touch required for fine control of the camera's motions and decoupling the camera from the cameraman's motions; and

3. minimum increased weight, that is,

eliminating the need for balancing counterweights, particularly in the case of the heavier 35 mm motion picture camera and video cameras.

In British Patent 1 528 032 in the name of Garrett Wood Brown (one of the applicants herein) there is disclosed a solution to the above given difficulties, namely portable camera equipment comprising a camera assembly including a support structure and components of a camera mounted spaced apart from one another on the support structure, a camera support means adapted to be mounted on the body of a camera operator in such a manner as to transmit the weight of the equipment to the body of the operator, the camera assembly being mounted at or substantially at the centre of gravity thereof on the camera support means, said camera support means being adapted to allow movement of the camera assembly when the equipment is installed on the body of the operator, upwardly downwardly and sideways of the operator, and said support means including spring means arranged to counterbalance at least partially the weight of the camera assembly whereby to tend to prevent movements of the body of the operator being transmitted through the support means to said camera assembly, and a viewfinder adapted to permit the camera operator to observe the field of view to be photographed by the camera notwithstanding changes in relative position of the camera and the operator. The disclosed support structure includes first and second support arms articulated to one another and each comprising links arranged in a parallelogram configuration, the first of the arms being rotatably mounted on a harness for the cameraman and the second of the arms being rotatably mounted on said camera assembly.

One disadvantage found in the function of the support arms disclosed in specification 1 528 032 is the possibility of one of the arms acting out of synchronism with the other arm, since in the disclosed device the arms are constrained to operate in a common plane. It is possible for parallelogram of one arm to close while the other arm is not yet closed. This severely restricts the range of operation. If it is attempted to raise the camera in a position close to the operator's body, it has been found that there is an arc in which the arms will not function. It is necessary to first push the camera forwardly whilst being raised and than to pull the camera rearwardly.

The present invention now provides a support structure for movably mounting a portable device on a movable carrier, comprising an arm structure having at one end thereof a first joint for connection to the movable carrier and at the other end thereof a second joint for connection to the portable device, the arm structure including first and second arms articulated to one another, the apparatus being so arranged that when attached to the movable carrier and carrying said portable device the arms can each effect a turning relative to one another and/or relative to the carrier so that each said arm can raise or lower the portable device relative to the carrier, at least one of the arms including first and second elongate links extending longitudinally of the arm, the links being mounted at each of their ends in the structure to turn about respective spaced apart generally parallel axes upon said turning of the link including arm, spring means acting on said arms for at least partially counterbalancing the weight of the portable device, and said articulation of the arms including means defining a pivot axis extending transversely of said parallel axes such that said arms can turn relative to one another about said pivot axis.

When used in the portable camera equipment aforesaid, the support structure of the present invention allows for improved movement of the camera relative to the camera operator, by virtue of said transversely extending pivot axis between the arms.

In order that the invention may be more fully understood and readily carried into effect an embodiment thereof will now be described with reference to the accompanying drawing, wherein like reference numerals denote like elements, and in which:

Figure 1 is a perspective view showing a support structure in accordance with the present invention in use but without a camera shown mounted thereon;

Figure 2 is a side elevation view of the structure of Figure 1 looking along the lines 2-2;

Figure 3 is a top plan view of the structure of Figure 1;

Figure 4 is a partial sectional side view of the structure of Figure 1;

Figure 5 is a partial sectional view of Figure 3 looking along the lines 5-5;

Figure 6 is an enlarged partial sectional view of Figure 5 looking along the lines 6-6;

Figure 7 is an enlarged partial sectional view of the structure as shown in Figure 4 looking along the lines 7-7;

Figure 8 is a partial sectional view of an alternative arrangement of the structure as shown in Figure 4 looking along the lines 7-7; and

Figure 9 is a modified enlarged partial view of the structure as shown in Figure 4 looking along the lines 9-9.

Referring to the drawings, Figures 1-7 illustrate one embodiment of a support structure for a weight such as a portable camera, in accordance with the present invention. Figure 1 is a perspective view of the support structure attached to a support vest which is worn by a cameraman. The support apparatus as shown in Figure 1 basically breaks down into five (5) portions. The first portion being that portion which is adapted to connect to the support vest. The second and third portions comprise

the forarm and upper arm. The fourth portion consists of a connection between the forearm and upper arm and the fifth portion consists of the end of the forearm which is arranged and configured such that a camera may be mounted thereon. The particular implementation of a support structure in accordance with the present invention will now be hereinafter discussed in reference to Figure 2-7.

In Figures 2-7, the support structure includes a pair of parallel upper arm links 2 and 4. The upper arm links 2 and 4 are pivotally coupled at one end to connector hinge bracket 6 , to turn about parallel, generally horizontal spaced apart axes. The other end of the upper arm links 2 and 4 are pivotally coupled to upper arm medial hinge bracket 8, to turn about parallel, generally horizontal spaced apertures. A second pair of parallel forearm links 10 and 12 are similarly pivotally coupled respectively between forearm medial bracket 14 and camera support bracket 16. Camera mounting pin 17 is provided in camera support bracket 16. Upper arm and forearm medial brackets 8 and 14 are coupled together along one side by a hinge 18 defining a generally vertical pivot axis. Connector hinge bracket 6 is coupled about a vertical pivot axis to one end of lower support hinge plate 20. The other end of lower support hinge plate 20 is coupled to fixed support block 22 by a pin 23. A spring 21 through which pin 23 extends, biases plate 20 in a clockwise direction.

One end of tension spring 24 is coupled to the end of upper arm link 2 which is pivotally coupled to upper arm medial hinge bracket 8. The other end of tension spring 24 is coupled to one end of tension spring 26 by a section of cable 28 which passes over and around pulley 30 which is rotatably coupled to upper arm link 2. The other end of tension spring 26 is coupled to one end of tension spring 32 via a section of cable 34 which rides on and around pulley 36 which is rotatably coupled to upper arm link 4. The other end of tension spring 32 is coupled to the end of upper arm link 4 adjacent connector hinge bracket 6.

Similar to the above, one end of tension spring 38 is coupled to the end of forearm link 10 adjacent to camera mounting bracket 16. The other end of tension spring 38 is coupled to tension spring 40 via a cable 42 which rides on and around pulley 44 which is rotatably coupled to one end of tension spring 46 via a cable 48 which rides on and around pulley 50 which is rotatably coupled to forearm link 12. The other end of tension spring 46 is coupled to the end of forearm link 12 adjacent forearm medial hinge bracket 14.

A weight, such as a camera which is supported at the support bracket 16 behaves as an object in free space beyond gravity since the upward forces which the tension springs 24, 26, 32 and 38, 40, 46 exert, in effect counteract gravity. The weight tends to travel in a straight line until influenced otherwise and tends to retain the same angle until influenced otherwise. In the configuration shown, the upper arm links 2, 4 roughly correspond to the upper arm (not shown) of the user in terms of its three dimensional geometry as it is used either high, low, or to either side.

The forearm links 10, 12 roughly correspond to the forearm of the user and roughly follows a parallel course to the user's forearm. The lower support hinge plate 20 provides the function of compensating for the motions to the front and to the rear of the user's shoulder. The lower support hinge plate 20 also allows the operator's arm to operate in the correct position for right handed use and swing the entire support arm structure to the left to allow the arms to operate out in front of the body for left handed use. The support hinge plate 20 also permits use back close to the user's shoulder and roughly parallel to the user's arm for right handed use. The support hinge plate 20 compensates for the necessary distance or movement of the operator's shoulder as the upper arm links 2, 4 traverse forward and to the rear as the operator (not shown) reaches forward and rearwardly.

The upper arm medial hinge bracket 8 allows the combined upper arm and forearm to act like the human arm and allows considerably more flexibility. The human arm can bend about only one axis at its elbow joint bracket 8 allows duplication of this movement by the upper arm and forearm. The hinged elbow permits the operation of the weight, such as a camera, to the right side of the user's body and close in with full up and down mobility without the arms locking. The hinged elbow and the lower support hinge plate 20 permit the same up and down mobility directly in front of the operator as close as can be. The lower support hinge plate 20 compensates for the movements of the operator's shoulder.

The hinged connection between two spring loaded parallelograms has no effect on their load bearing ability even as the hinge is deployed throughout its entire range.

Furthermore, a shuber spring 47 and shuber spring mounting block 49 are provided on both sides of the upper ends of forearm link 10 and upper arm link 2. The shuber spring 47 and shuber spring mounting block 49 are arranged and configured such that at the upper limit of movement of the support apparatus the shuber springs engage with upper arm medial hinge bracket 8 and camera mounting bracket 16 and at the lower limit of movement engage with the top edge of upper arm link 4 and forearm link 12.

The coupling of one end of the tension spring to a link will now be described in detail by referring to Figures 5 and 6. In Figure 5, the tension spring 38 is threaded onto a cylindrical block 52 having a helical groove pattern 54 formed in the outside cylindrical surface. A

mounting bracket 56 is formed in the end of forearm link 10. Cylindrical block 52 is coupled to mounting bracket 56 by a bolt 58 which passes through washer 60, a hole in support bracket 56 and a hole 62 in hollow cylindrical block 52 having a nut 64 swaged onto the end projecting through hole 62 in hollow cylindrical block 52. Furthermore, washer 60 has two fins 61 projecting axially from its surface which pass through two slots 63 in bracket 56 and engage two slots 65 on the inner cylindrical surface of block 52 thereby preventing rotation of block 52. Furthermore, as a result of swaging nut 64 being nonrotatably coupled to hollow cylindrical block 52, the tension on the spring assembly can be adjusted by rotating bolt 58 clockwise or counterclockwise.

Referring to Figure 7, shown therein is an example of a low friction self-centering rotatable coupling between an link and a bracket. In particular, connector hinge bracket 6 is provided with pairs of opposing holes 70. Link 2 is provided with pairs of opposing holes 72 into which bearings 74 are mounted. A pair of coupling pins 76 are inserted through holes 70 in connector hinge bracket 6 and into bearing 74 mounted in hole 72 of arm 2. In order to eliminate any sliding friction between arm 2 and connector hinge bracket 6 and to maintain the link 2 in a fixed position a pair of thrust bearings 78 is provided between the inside surface of connector hinge bracket 6 and the outside surface of upper arm link 2. In this manner, the rotational friction between connector hinge bracket 6 and upper arm link 2 is kept to a minimum.

Referring further to Figure 7, shown therein is a means for connecting the cable to one end of the tension springs. The means for coupling the cable to one end of the tension springs consists of a cylindrical hollow block 80. The hollow cylindrical block 80 is further provided with a slot 82 which extends from the side of the cylindrical block 80 to its centre. The bottom inside surface of hollow cylindrical block 80 is further provided with a conical depression 84 and a helical groove 86 is formed in the outside surface of hollow cylindrical block 80.

To couple the cable to the spring, first the cable having a ball fixed to its end is slipped into the slot 82 in hollow cylindrical block 80. The ball fixed to the end of cable 28 fits into conical depression 84 thereby holding the cable in the centre of the cylindrical hollow block 80. Spring 24 is then threaded onto the helical groove 86 formed in the outside surface of hollow cylindrical block 80.

In practice the length of the support apparatus should be approximately equal to the length of the arm of a cameraman. Furthermore, the bearings 78 and 74 may be any type of low friction bearing which exists in the art and which performs the desired function. In addition, the support may be made up of any number of arms greater than one (1) arm. Furthermore, the camera may be similar to the expanded camera disclosed in British Patent Specification 1 528 032 wherein various camera parts are mounted spaced apart on a frame to increase the moment of invention and hence the resistance to rotation from perturbing forces produced for example by running with the equipment.

In operation, the segmented spring comprising tension springs 24, 26 and 32 interconnected by cables 28 and 34 act together as a single tension spring mounted diagonally across the parallelogram formed by upper arm links 2 and 4 and connector hinge bracket 6 and upper arm medial hinge bracket 8. This equivalent tension spring exerts a force which is equal to the weight applied to the end of the parallelogram times the length of the diagonal of the parallelogram along which the spring extends divided by the distance between the attachment points of links 2 and 4 on upper arm medial hinge bracket 8. Accordingly, the equivalent diagonal tension spring exerts a force which exactly compensates for the weight applied to the end of the parallelogram regardless of how the parallelogram is moved in a vertical plane. Therefore, once the equivalent tension spring is adjusted to compensate for the weight applied to the end of the parallelogram, in this case to the upper arm medial hinge bracket 8, it will exactly compensate for this weight at all angles of movement. For the parallelogram consisting of upper arm links 2 and 4 and connector hinge bracket 6 and upper arm medial hinge bracket 8, the weight applied consists essentially of the remainder of the support apparatus plus the weight of the camera.

Similarly to that previously described, a segmented spring consisting of tension springs 38, 40 and 46 interconnected by cables 42 and 48 act as a diagonal tension spring extending across the diagonal parallelogram consisting of forearm links 10 and 12 and forearm medial hinge bracket 14 and camera support bracket 16. For the parallelogram consisting of links 10 and 12 and forearm hinge bracket 14 and camera support bracket 16, the weight applied consists substantially of the weight of the camera mounted on the camera support bracket 16.

Furthermore, at the extremities of movement of the support apparatus there are large moments applied to the ends of the forearm and upper arm which tend to distort the parallelogram. Since there are these large moments, shuber springs 47 are provided to exert a counteractive force at the extremeties of movement of the support apparatus to prevent distortion of the parallelogram and ensure smooth operation over the full range of movement.

Since as previously described, the weight applied to each section of the support apparatus is exactly compensated by that sections

equivalent diagonal spring, the weight of the camera fixed on camera support bracket 16 is exactly compensated at all positions of the support apparatus. Furthermore, since the weight of the camera is compensated for at all positions of the support apparatus and there is a very small amount of friction in the linkage of the support apparatus, substantially none of the motion of the cameraman is transmitted to the camera as a result of the camera's own inertia. Therefore, it is possible for the cameraman to move up and down without affecting the position of the camera mounted on the support apparatus. To provide for motion in the horizontal plane, hinge 18 allows the upper arm and forearm section of the support apparatus to turn relative to each other as shown by the curved arrow in Figure 3. Furthermore, the support apparatus may turn relative to the cameraman at the pivotal connection of hinge bracket 6 and lower support hinge plate 20. As a result of this allowable movement and in particular the movement of the upper arm relative to the forearm, the mobility of the cameraman is increased.

For those situations where the camera is very heavy, it may be desirable to modify the support apparatus as shown in Figures 8 and 9. In this modification the single cable 42 between the tension springs is replaced by a double cable 42'. Since there are two cable 42' the pulley 44 must be modified as shown by the pulley 44' in Figure 8 to accommodate the two cables 42'. Furthermore, the cylindrical block which couples the cables to the tension spring 38 must also be modified to two cables as shown by the cylindrical block 80'.

In particular, the cylindrical block 80' is provided with a concave seat 81 which engages with rocker 83. The rocker 83 engages with the balls on the ends of cables 42' and compensates for the variations which occurs in cable length thereby insuring that the load is divided equally between the cables 42'.

Referring to Figure 9, shown therein is a modified form of the diagonal spring 40 with the additional modification of a safety cable. In Figure 9 the cylindrical blocks 88 are provided not only with a means for coupling the cables 42' to the block 88 and a helical groove onto which the tension spring 40 is threaded, but also a projection 90 to which a safety cable 92 is attached. In this way if the tension spring 40 were to break or to become disconnected from the hollow cylindrical block 88, the safety cable 92 would prevent the spring from flying off and causing injury to someone and also would prevent the total collapse of the support apparatus. Furthermore, it should be apparent that the spirng 26 could be modified in a similar manner as the spring 40 shown in Figure 9.

Furthermore, it should be apparent to one skilled in the art that the above described support apparatus could be coupled to any means of support other than a cameraman; i.e. a car, horse, aeroplane, etc. In addition, the support apparatus could be used to support many other devices besides a camera; i.e. a weapon, an instrument, etc. Also, it should be apparent that any configuration of springs whether internal or external which exerts the desired force on the diagonal of the parallelogram would operate equally as well as that described.

WHAT WE CLAIM IS:—

1. A support structure for movably mounting a portable device on a movable carrier, comprising an arm structure having at one end thereof a first joint for connection to the movable carrier and at the other end thereof a second joint for connection to the portable device, the arm structure including first and second arms articulated to one another, the apparatus being so arranged that when attached to the movable carrier and carrying said portable device the arms can each effect a turning relative to one another and/or relative to the carrier so that each said arm can raise or lower the portable device relative to the carrier, at least one of the arms including first and second elongate links extending longitudinally of the arm, the links being mounted at each of their ends in the structure to turn about respective spaced apart generally parallel axes upon said turning of the link including arm, spring means acting on said arms for at least partially counterbalancing the weight of the portable device, and said articulation of the arms including means defining a pivot axis extending transversely of said parallel axes such that said arms can turn relative to one another about said pivot axis.

2. A support structure according to Claim 1 wherein said spring means includes for said link including arm, a spring connected at one end of the arm to the first link, the spring being connected to the second link at the other end of the arm.

3. A support structure according to Claim 1 wherein said spring means includes for said link including arm, first and second tension springs attached to opposite ends of the arm respectively, the springs each extending from the attachment thereof along a respective one of the links towards a pulley on the link, a third tension spring disposed between the links, and means connecting the ends of the third spring to the first and second springs respectively, said means extending over the pulleys.

4. A support structure according to Claim 3 wherein said means extending over the pulleys comprise substantially inextensible cables.

5. A support structure according to Claim 3 or 4 wherein each said spring is provided with an internal safety cable to prevent the spring flying off and causing injury and to prevent total collapse of the structure if one of the springs should fail.

6. A support structure according to any preceding claim wherein said links are generally parallel to one another and are of substantially the same length so as to define opposite relatively long sides of a parallelogram having its corners aligned with said parallel axes.

7. A support structure according to Claim 6 wherein said spring means is arranged to apply a force along the diagonal of said parallelogram, which force is equal to the force applied to the end of the parallelogram times the length of the diagonal divided by the length of the relatively short side of the parallelogram.

8. A support structure according to any preceding Claim 1 wherein the other arm includes a pair of elongate links extending longitudinally of the arm, the links being mounted at each of their ends to turn about respective axes parallel to the axes of said one arm.

9. A support structure according to any preceding claim wherein the articulation of the arms includes a hinge defining said pivot axis.

10. A support structure according to any preceding claim wherein said first joint for connection to the carrier includes at least one hinge having its hinge axis parallel to said pivot axis.

11. A support structure according to any preceding claim and including a harness for fitment to the body of an operator, the harness being coupled to said first joint.

12. A support structure according to any preceding claim and including a camera mounted on said second joint.

13. A support structure substantially as hereinbefore described with reference to the accompanying drawings.

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1589062 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

**Sheet 1**

*Fig. 1*

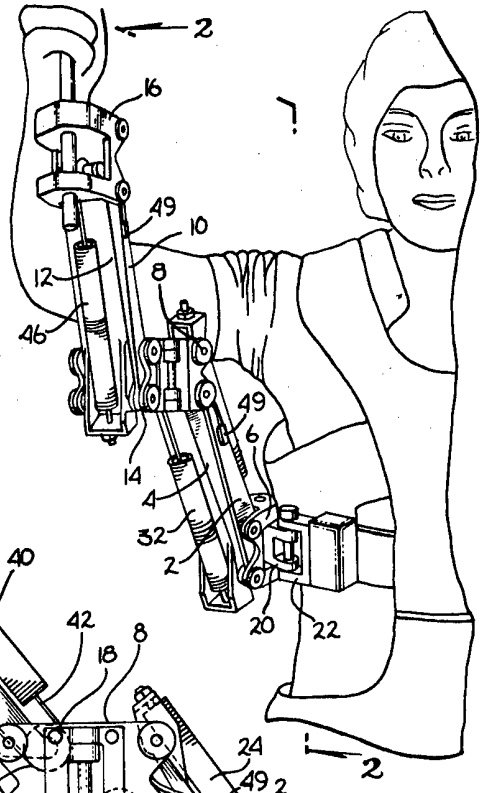


*Fig. 2*

1589062 COMPLETE SPECIFICATION

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Sheet 2

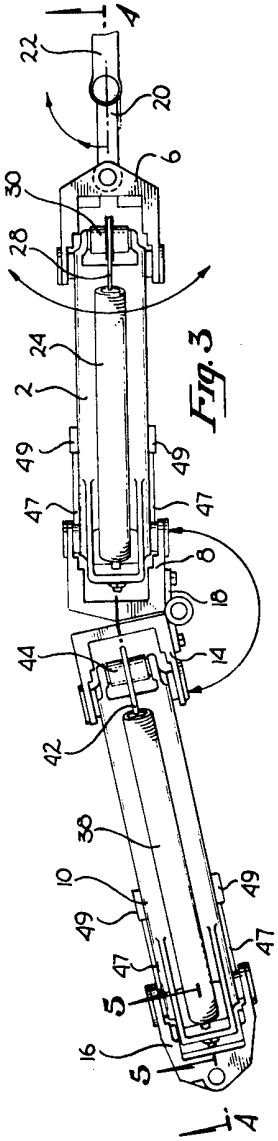

Fig. 3

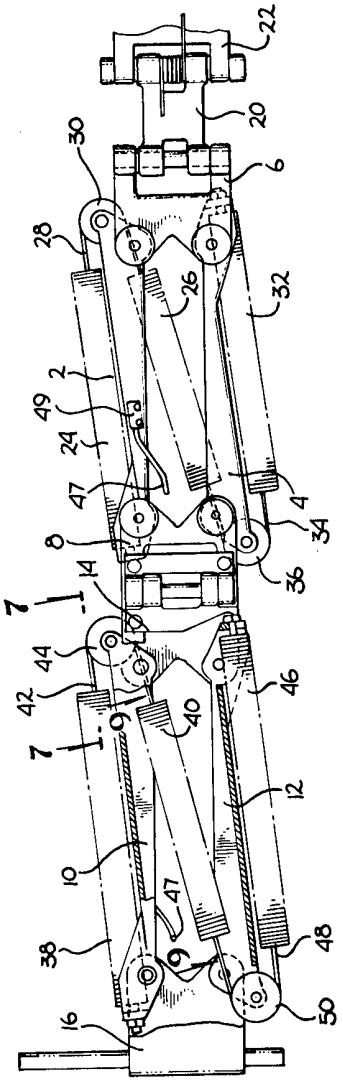

Fig. 4

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Sheet 3

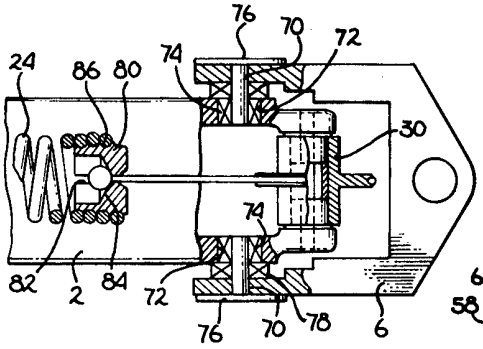


*Fig. 7*

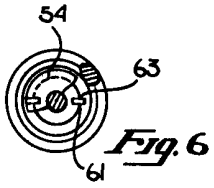


*Fig. 6*

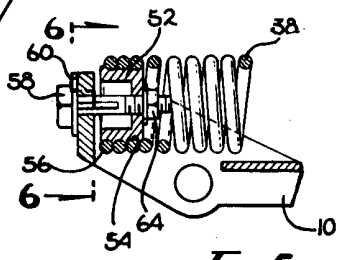


*Fig. 5*

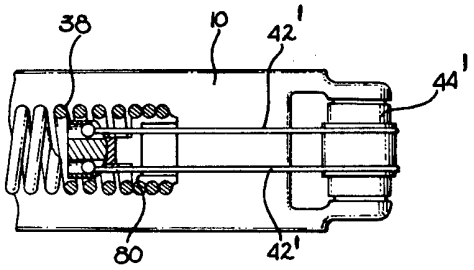


*Fig. 8*

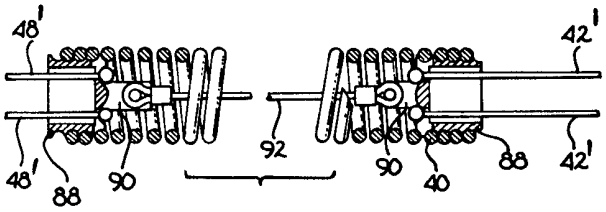


*Fig. 9*