Jan. 5, 1965 E. O. SEITZ ETAL 3,164,355

SUSPENDING ARRANGEMENT

Filed May 8, 1963 2 Sheets-Sheet 1

Fig. 1

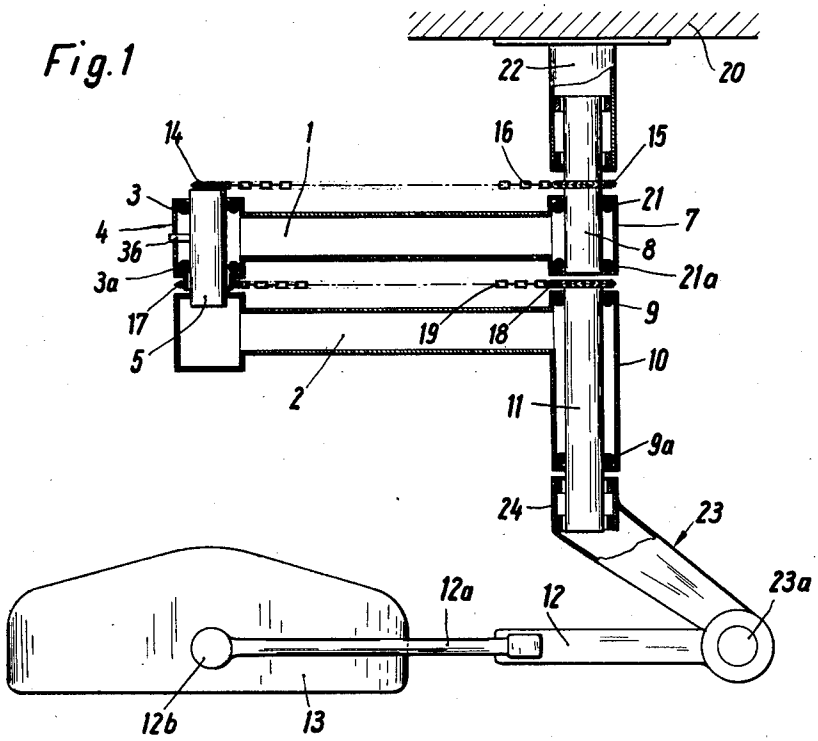

Fig. 3

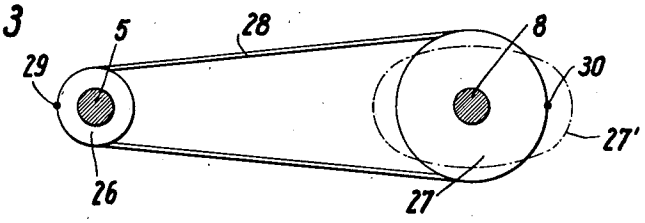

Fig. 4

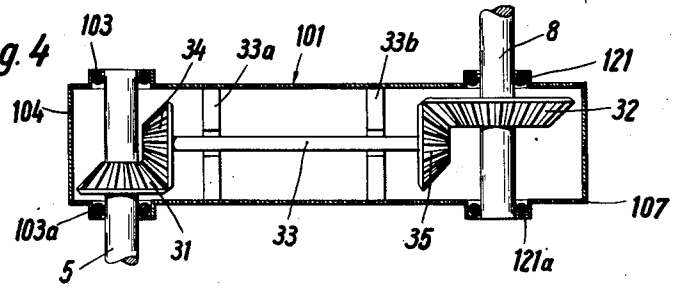

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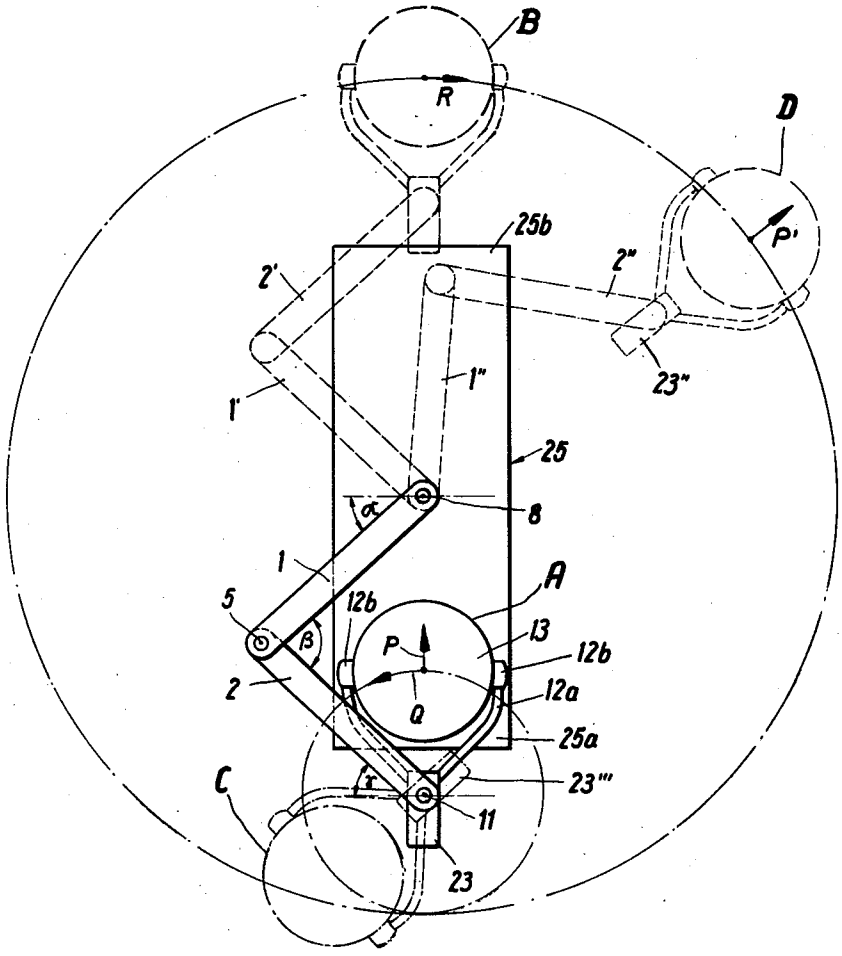
Fig. 2



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SUSPENDING ARRANGEMENT

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11 Claims. (Cl. 248—324)

The present invention relates to suspending arrangements in general, and more particularly to an improved suspending arrangement whose operation is somewhat similar to that of lazy tongs and which is especially suited to serve as a means for supporting and for changing the position of lamps, cameras, columns and other pieces of operating room equipment.

It is already known to suspend a lamp or another piece of operating room equipment on a structure comprising two or more arms which are rotatable in horizontal planes and which are articulately connected to each other. A serious drawback of such conventional suspending arrangements is that the operator (for example, a nurse or a physician) cannot exercise full control over the movements of all of the interconnected arms if one thereof is swung in an effort to move the lamp to a different position. In other words, unless the operator uses both hands, there is no possibility to determine in advance the exact direction of movement of the suspended object, and even two hands are not enough if the suspending arrangement comprises three or more relatively movable arms. This is mainly due to the fact that friction between the cooperating elements of articulate connections between the relatively movable arms is not the same so that a readily rotatable arm is more likely to change its angular position than the remaining arm or arms; consequently, the suspended object may reach a given position in a number of ways and the operator never knows which way the relatively movable arms will select to reach a new position. For example, if the operator desires to move the suspended object in a substantially straight path, the path of the object must be watched while the object is being transferred to a new position, and the situation is even more complicated if the suspending arrangement is equipped with a motor which serves as a means for changing the position of the suspended object or objects.

On the other hand, it is a well known fact that a lamp or another piece of operating room equipment must be moved more frequently between two or more specific positions, i.e., that the surgeon might wish to shift the lamp in a direction from the head end to the foot end of an operating room table, whereas movements of the lamp in certain other directions are much less frequent. When a patient is placed onto the operating room table, the surgeon or his assistants will normally require light from above so that it is often sufficient to mount the lamp in such a way that the lamp may be shifted longitudinally of the table. Of course, this could be achieved by providing elongated guides or rails along the ceiling and by suspending the lamp or lamps from a carriage or runner which is arranged to travel along such rails. As simple as it might appear, such solution would be quite unsatisfactory because it happens again and again that the lamp must be moved to a given position laterally of the operating room table or far away and out of reach of persons attending a patient so that the utility of a lamp which is prevented from moving in directions other than in a given path would be utterly limited.

Accordingly, it is an important object of the present invention to provide a very simple suspending arrangement which is constructed and assembled in such a way that

the objects which are suspended thereon are normally restricted to reciprocatory movements in a given path, but which is nevertheless capable of permitting such suspended objects to assume any desired number of other positions which are comparatively close to or which are rather distant from the given path.

Another object of the invention is to provide a suspending arrangement of the just outlined characteristics which is constructed and assembled in such a way that the position of the path for reciprocatory movements of one or more suspended objects may be changed at will and with comparatively little effort so that such suspending arrangement may be readily manipulated by nurses, convalescents, children or older persons.

A further object of the invention is to provide a suspending arrangement which may be secured to a fixed support (such as the ceiling of an operating room) at a single point or at two or more points.

An additional object of the invention is to provide a very simple but highly reliable transmission which enables the improved suspending arrangement to move one or more suspended objects in such a way that the objects may remain parallel to themselves.

A concomitant object of the instant invention is to provide a transmission which may be concealed from view so that it is not exposed to dust or moisture, that it cannot injure the hands of the operator, that the exterior of the component part which accommodates the transmission may be readily cleaned, and that such part is less likely to collect dust.

Another object of our invention is to provide a suspending arrangement which may be furnished in many different sizes and/or shapes, which may be collapsed to occupy little space when not in actual use, and which may support a single object or a substantial number of objects so that such supported or suspended objects may travel in a single path or in separate paths.

A further object of the invention is to provide a suspending arrangement which may move one or more suspended objects to an infinite number of positions from a central point and which can move such objects through equal distances diametrically across the central point so that the various paths form a pattern of rays which emanate from a fixed center.

With the above objects in view, one feature of the invention resides in the provision of a suspending arrangement, particularly for supporting certain types of operating room equipment, such as one or more lamps, a camera, a column for nozzles which discharge laughing gas, or the like. The suspending arrangement comprises a supporting member, e.g., a pivot which may be fixed to the ceiling of an operating room, a first supported member one end portion of which constitutes with the supporting member a first swivel joint so that the supported member may rotate about the normally vertical axis of this swivel joint, a second supported member having a portion which constitutes with the other end portion of the first supported member a second swivel joint whose axis is normally parallel with the axis of the first joint and which enables the second supported member to rotate with respect to the first supported member, and a transmission which connects the supporting member with the aforementioned portion of the second supported member so that the first supported member is compelled to rotate about the axis of the first swivel joint when the second supported member is caused to rotate about the axis of the second swivel joint, or vice versa. The lamp or another piece of operating room equipment may be secured to the second supported member, and the arrangement is preferably such that the ratio of the transmission is two-to-one which means that the angular distances covered

by the first supported member about the axis of the first swivel joint equal one-half the angular distances covered by the second supported member about the axis of the second swivel joint.

The transmission may be a purely mechanical structure, but it is equally possible to utilize a current-operated transmission or a transmission whose ratio may vary in response to changes in angular position of the supported member or members.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved suspending arrangement itself, however, both as to its construction and its method of operation, together with additional features and advantages thereof, will be best understood from the following detailed description of certain specific embodiments with reference to the accompanying drawings, in which:

FIG. 1 is a somewhat schematic partly elevational and partly vertical sectional view of a suspending arrangement with three supported members which embodies one form of our invention;

FIG. 2 is a schematic top plan view of the suspending arrangement which is shown installed at a level above an operating room table and whose lowermost supported member carries a lamp which is illustrated in four different positions;

FIG. 3 is a schematic top plan view of a modified transmission which may be utilized in the suspending arrangement of FIGS. 1 and 2; and

FIG. 4 is a schematic vertical section through a hollow supported member which accommodates a bevel gear transmission.

Referring now in greater detail to the drawings, and first to FIG. 1, there is shown a suspending arrangement which is intended to support a lamp 13 at a level above an operating room table 25, see FIG. 2, and to permit this lamp to assume a series of different positions with respect to the operating room table. The suspending arrangement includes a supporting member here shown as a pivot 8 which is rotatable with at least some friction in a bearing sleeve 22, the latter forming part of a fixture which is secured to the ceiling 20 in such a way that the pivot 8 may rotate about a fixed vertical axis. The lower part of the pivot 8 rotatably supports a ring-shaped end portion 7 of a first supported member 1 which assumes the form of an elongated arm and which is rotatable about the vertical axis of the pivot 8. This pivot 8 and the end portion 7 together form a swivel joint which enables the arm 1 to rotate in a substantially horizontal plane. Friction between the pivot 8 and the end portion 7 is reduced by a set of antifriction bearings 21, 21*a* to insure that the pivot will not tend to rotate in the sleeve 22 when the arm 1 is caused to rotate about the axis of the swivel joint 7, 8.

The other end portion 4 of the arm 1 also assumes the form of a ring which receives a pivot- or shaft-shaped end portion 5 of a second supported member 2. This second supported member also assumes the form of a horizontal arm which is rotatable about the vertical axis of the swivel joint defined by the end portions 4, 5. It will be noted that the end portion or pivot 5 rotates in antifriction bearings 3, 3*a* to insure that the pivot 8 is not compelled to rotate in the sleeve 22 when the arm 2 is caused to rotate about the axis of its end portion 5. The axes of the swivel joints 7, 8 and 4, 5 are parallel to each other, and the arm 2 is rotatable in a horizontal plane which is located at a level beneath the level of the arm 1.

The other end portion 10 of the lower arm 2 assumes the form of a sleeve which constitutes one component of a third swivel joint, and this swivel joint further includes a vertical pivot 11 which rotates in a pair of antifriction bearings 9, 9*a* provided in the interior of the end portion 10. The lower part of the pivot 11 is frictionally received in a bearing sleeve 24 which constitutes the upper end portion of an inclined link 23. The lower end portion of this link carries a hinge whose horizontal pintle 23*a* provides a pivot axis for a second link 12 having a bifurcated portion 12*a* provided with inwardly extending pins 12*b* which carry the frame of the lamp 13 in such a way that the latter is rotatable about a horizontal axis which is the common axis of the pins 12*b*. Friction between the sleeve 24 and the pivot 11 is greater than that between the pivot 11 and the end portion 10.

In accordance with our invention, the suspending arrangement further comprises a transmission which serves as a means for compelling the arm 1 to rotate about the axis of the swivel joint 7, 8 when the arm 2 is caused to rotate about the axis of the swivel joint 4, 5, or vice versa. Furthermore, the ratio of this transmission is preferably two-to-one which means that the angle beta (see FIG. 2) covered by the arm 2 when the latter is caused to rotate about the axis of the swivel joint 4, 5 equals two angles alpha described by the arm 1 about the swivel joint 7, 8. The transmission comprises a small sprocket 14 which is coaxially fixed to the upper part of the pivot 5, a larger sprocket 15 which is coaxially fixed to the pivot 8 at the level of the sprocket 14, and an endless chain 16 which is trained around the sprockets 14, 15. A second transmission of similar construction is arranged to compel the lower arm 2 to rotate about the axis of the swivel joint 4, 5 in response to rotation of the link 23 about the axis of the swivel joint 10, 11. The parts 23, 12 together form a third supported member which is connected to the lower arm 2 by the aforementioned swivel joint 10, 11. The pivot 11 constitutes the end portion of this third supported member. The second transmission (whose ratio is two-to-one) again comprises sprocket 18 which is coaxially fixed to the pivot 11, and an endless chain 19 which is trained around the sprockets 17, 18.

The angle gamma (see FIG. 2) covered by the third supported member 12, 23 when the latter rotates about the vertical axis of the swivel joint 10, 11 equals one half the angle beta described by the arm 2 about the axis of the swivel joint 4, 5. Consequently, the lamp 13 is compelled to move in a horizontal plane when one of the three supported members is caused to rotate about the axis of the respective swivel joint. This is shown in FIG. 2 which illustrates the suspending arrangement in a series of different positions. The lamp 13 may be moved from a starting position A (shown in full lines) toward and into a second position B by moving in a horizontal plane in response to rotation of the arm 1 in a clockwise direction (as viewed in FIG. 2) which corresponds to a counterclockwise rotation of the arm 2 and to a clockwise rotation of the link 23. The lamp then travels in the direction indicated by an arrow P in a horizontal plane so as to advance from the head end 25*a* toward and beyond the other end 25*b* of the operating room table 25. The arms 1, 2 then respectively assume the heavy broken-line positions 1', 2'. While the lamp moves from the position A to the position B, the pivot 11 travels along a straight line (arrow P).

If the operator desires to move the lamp 13 from the position B to the position D (shown in lighter broken lines), the arms 1, 2 must be held against rotation about the respective swivel joints but the pivot 8 must be caused to rotate in the sleeve 22 so that the lamp travels in the direction indicated by an arrow R but its distance from the axis of the pivot 8 remains unchanged. Should it become necessary to increase the distance between the lamp 13 (in the position D) and the pivot 8, the operator merely rotates the arm 1 (from the position 1'') in a clockwise direction so as to bring about anticlockwise rotation of the arm 2 (from the position 2'') and clockwise rotation of the link 23 (from the position 23'') whereby the lamp moves in the direction indicated by an arrow P' and advances radially outwardly and away from the pivot 8.

On the other hand, if the operator desires to move the lamp 13 from the position A to a position C (which

is shown in phantom lines), he must overcome friction between the pivot 11 and the sleeve 24 in order to rotate the sleeve 24 in a counterclockwise direction by simultaneously preventing angular displacements of the arms 1, 2 about the axes of the respective swivel joints. The link 23 then describes an angle gamma and moves to the phantom-line position 23'''. The direction of such movement of the link 23 is indicated by an arrow Q, and the movement takes place on the periphery of a circle whose center is located on the axis of the pivot 11. In a following step, the operator may move the arm 1 to the position 1' or 1'' whereby the lamp 13 remains parallel to itself as long as the pivot 8 does not rotate in the sleeve 22 or as long as the sleeve 24 does not rotate with respect to the pivot 11.

It will be readily understood that the lamp 13 may be moved to an infinite number of additional positions by combining movements of the parts 1, 2, 23 about the axes of the respective swivel joints with movements of the pivot 8 in the sleeve 22, with movements of the sleeve 24 about the pivot 11, with movements of the link 12 about the pintle 23*a* and/or with movements of the lamp 13 about the common axis of the pins 12*b*.

If the ratio of the transmission 14–16 is one-to-one, the lamp 13 will travel in an arcuate path whose center of curvature does not coincide with the axis of the pivot 8.

FIG. 3 illustrates a modified transmission which may be utilized in the suspending arrangement of FIGS. 1 and 2 as a substitute for the transmission 14–16 and/or 17–19. This transmission comprises a pair of pulleys including a smaller pulley 26 which may be mounted on the pivot 5 as a substitute for the sprocket 14, a larger pulley 27 which may be mounted on the pivot 8 as a substitute for the sprocket 15, and an endless flexible belt 28 which replaces the chain 16. That arcuate portion of the belt 28 which engages the pulley 26 is connected with this pulley along a short section 29, and a similar short section 30 of this belt is connected to the pulley 27 to prevent slippage of the belt. Of course, the transmission of FIG. 3 is satisfactory only when the pivot 5 need not rotate through angles which exceed 90 degrees, but the pivot is free to rotate through up to 90 degrees in a clockwise or counterclockwise direction with reference to the position of FIG. 3, i.e., the angle beta should not exceed 90 degrees.

FIG. 4 illustrates a further transmission which is mounted in a hollow supported member 101. This supported member is analogous to the arm 1 and its end portions 107, 104 assume the form of rings which are respectively rotatable about the pivots 8, 5. Antifriction bearings 121, 121*a* surround the pivot 8, and a similar set of antifriction bearings 103, 103*a* is disposed between the parts 104, 5 which together form a swivel joint having an axis which is parallel with the axis of the swivel joint 107, 8. The modified transmission comprises a bevel gear 32 which is coaxially fixed to the pivot 8 and which is accommodated in the end portion 107, a smaller second bevel gear 31 which is coaxially fixed to the pivot 5 and which is accommodated in the end portion 104, a shaft 33 which is rotatable in bearings 33*a*, 33*b* provided in the interior of the supported member 101, a third bevel gear 34 which is coaxially fixed to one end of the shaft 33 and which mates with the gear 31, and a fourth bevel gear 35 which mates with the gear 32 and which is coaxially fixed to the other end of the shaft 33. The operation of the bevel gear transmission of FIG. 4 is obviously analogous to that of the transmission shown in FIG. 3 or to the operation of the transmissions shown in FIG. 1. An important advantage of the bevel gear transmission is that it may be fully concealed in the supported member 101 so that it is less prone to malfunction, that it need not be lubricated at frequent intervals, that it is not likely to injure the hand of a nurse, of a doctor or of another person on duty in the operating room, and that it does not comprise any components (such as the chains 16, 19 or the belt 28) which might be caused to expand after extended periods of use.

The improved suspending arrangement is capable of many additional modifications which are in part so obvious that they can be readily comprehended without necessitating illustration. Thus, the lamp 13 and/or another piece of operating room equipment may be mounted on the arm 2 (for example, beneath or close to the pivot 5) and the pivot 11 may be rotatably received in a fixed sleeve similar to the sleeve 22. It is also possible to mount the link 12 for rotation about a fixed axis which is distant from the pivot 11 and to suspend the lamp 13 on the arm 2, on the link 23 or on the link 12. Furthermore, the ring-shaped end portions 4, 7 and 10 may assume the form of pivots and the pivots 8, 5, 11 may assume the form of sleeves or tubes.

As stated hereinabefore, the ratio of the transmissions shown in FIGS. 1–2, 3 and 4 need not always be two-to-one, i.e., it might be desirable to use a transmission which causes the lamp 13 or another piece of operating room equipment to travel in a manner other than in parallelism with itself. The transmission of FIG. 3 is especially suited for use in suspending arrangements wherein the transmission ratio should vary in different stages of rotation of the pivot 5 or 8. This can be achieved by utilizing a non-circular pulley 27' (shown in phantom lines) as a substitute for the pulley 27.

Referring again to FIG. 1, there is shown a brake 36 which is carried by the end portion 4 and which is arranged to act against the pivot 5 to regulate friction between the component parts of this swivel joint. Such brake is necessary to prevent uncontrolled (particularly too fast) movements of the suspending arrangement in response to a push against one of the supported members. If desired, each swivel joint may be provided with a brake.

The number of swivel joints and the number of supported members may be increased to four or more, depending on desired maximal span of the arrangement.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic and specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. A suspending arrangement for supporting a piece of operating room equipment in an operating room, comprising a supporting member adapted to be fixed to a ceiling of an operating room; a first pivot having a vertical axis and forming part of said supporting member; a first supported member including an arm having a first end portion rotatably mounted on said pivot and a second end portion; a second supported member comprising a second pivot having an axis which is parallel to the axis of said first pivot, said second pivot being rotatably received in said second end portion; means on one of said members for supporting a piece of operating room equipment; and a transmission connecting said pivots to each other and arranged to compel said first supported member to rotate about the axis of said first pivot when the second supported member is caused to rotate about the axis of said second pivot or vice versa whereby a piece of operating room equipment supported by said one member moves in a substantially horizontal plane.

2. A suspending arrangement for supporting a piece of operating room equipment in an operating room, comprising a supporting member adapted to be fixed to a ceiling of an operating room; a first pivot having a vertical axis and forming part of said supporting member; a first supported member including an elongated arm having a first end portion rotatably mounted on said pivot

and a second end portion; a second supported member comprising a second pivot rotatably received in said second end portion and having an axis which is parallel with the axis of said first pivot; means on one of said members for supporting a piece of operating room equipment; and a transmission connecting said pivots to each other and arranged to compel said first supported member to rotate about the axis of said first pivot in a clockwise direction when the second supported member is caused to rotate about the axis of said second pivot in a counterclockwise direction or vice versa whereby a piece of operating room equipment supported by said one member moves in a substantially horizontal plane.

3. A suspending arrangement as set forth in claim 2, wherein said ratio of said transmission is two-to-one so that the angular distances covered by said first supported member about the axis of said first pivot equal one-half the angular distances covered by said second supported member about the axis of said second pivot.

4. A suspending arrangement, particularly for supporting a piece of operating room equipment, comprising a supporting member; first bearing means rotatably supporting said supporting member so that the latter is rotatable with at least some friction about a fixed axis; a first supported member having a first and a second end portion, said supporting member and said first end portion together forming a first swivel joint and said supported member being rotatable about the axis of said swivel joint; a second supported member having a first and a second end portion, the first end portion of said second supported member forming with the second end portion of said first supported member a second swivel joint whose axis is parallel with the axis of said first swivel joint and said second supported member being rotatable about the axis of said second swivel joint; a third supported member having a portion forming with the second end portion of said second supported member a third swivel joint whose axis is parallel with the axis of said first swivel joint and said third supported member being rotatable about the axis of said third swivel joint, said third supported member further comprising second bearing means for said portion thereof so that said third supported member is rotatable with at least some friction with respect to said last mentioned portion; antifriction bearings provided in said swivel joints so that friction in said joints is less than the friction between said first bearing means and said supporting member or between said second bearing means and said portion of the third supported member; a first transmission connecting the supporting member with the first end portion of said second supported member and arranged to compel said first supported member to rotate about the axis of said first swivel joint when said second supported member rotates about the axis of said second swivel joint or vice versa; and a second transmission connecting the second end portion of said first supported member with the portion of said third supported member and arranged to compel said second supported member to rotate about the axis of said second swivel joint in response to rotation of said third supported member about the axis of said third swivel joint or vice versa.

5. A suspending arrangement as set forth in claim 4, wherein said bearing means are bearing sleeves and wherein said antifriction bearings comprise friction-reducing rolling elements.

6. A suspending arrangement for supporting a piece of operating room equipment from the ceiling of an operating room, comprising a supporting member adapted to be fixed to the ceiling; a first supported member having a first end portion and a second end portion, said supporting member and said first end portion together forming a first swivel joint having a vertical axis and said supported member being rotatable about the axis of said swivel joint; a second supported member having a portion constituting with said second end portion a second swivel joint having a vertical axis and said second supported member being rotatable about the axis of said second swivel joint; a lamp; connecting means securing said lamp with said second supported member; and a transmission connecting said supporting member with said portion of the second supported member and arranged to compel said first supported member to rotate about the axis of said first swivel joint when the second supported member rotates about the axis of said second swivel joint or vice versa whereby said lamp moves along predictable paths in a horizontal plane in response to movement of either of said supported members.

7. A suspending arrangement, particularly for supporting a piece of operating room equipment, comprising a supporting member; a first supported member having a first end portion and a second end portion, said supporting member and said first end portion together forming a first swivel joint and said supported member being rotatable about the axis of said swivel joint; a second supported member having a portion constituting with said second end portion a second swivel joint and said second supported member being rotatable about the axis of said second swivel joint; a lamp; connecting means securing said lamp with said second supported member, said connecting means comprising at least one hinge having a pintle whose axis is perpendicular to the axes of said swivel joints so that the lamp may be moved angularly with respect to said second supported member; and a transmission connecting said supporting member with said portion of the second supported member and arranged to compel said first supported member to rotate about the axis of said first swivel joint when the second supported member rotates about the axis of the second swivel joint or vice versa.

8. A suspending arrangement as set forth in claim 6, wherein said transmission comprises a first sprocket coaxially fixed to said first joint, a second sprocket coaxially fixed to said second joint, and an endless chain trained around said sprockets.

9. A suspending arrangement as set forth in claim 6, wherein said transmission comprises a first pulley coaxially fixed to said first swivel joint, a second pulley coaxially fixed to said second swivel joint, and an endless belt trained around said pulleys.

10. A suspending arrangement as set forth in claim 6, wherein said first supported member comprises an elongated hollow arm and said transmission comprises a first and a second bevel gear respectively fixed to and coaxial with said first and second swivel joints, said gears being respectively accommodated in said first and second end portions of said first supported member, a shaft rotatably mounted in said hollow arm, and a pair of bevel gears coaxially fixed to said shaft and respectively mating with said first and second bevel gears.

11. A suspending arrangement as set forth in claim 6, wherein said second supported member is rotatable about the axis of said second swivel joint through an angle greater than 360° and said first supported member is rotatable about the axis of said first swivel joint through an angle greater than 360°.

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