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[54] **DEVICE FOR INDICATING THE POSITION OF THE PLATFORM OF CRANES WITH ARTICULATED BOOMS, ESPECIALLY CAMERA CRANES**
7 Claims, 4 Drawing Figs.

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[51] **Int. Cl.** **G01d 21/00**
[50] **Field of Search** **116/114;** 124, 135; 95/86; 352/34, 243; 182/141, 2; 248/11, 124, 125, 183; 280/91

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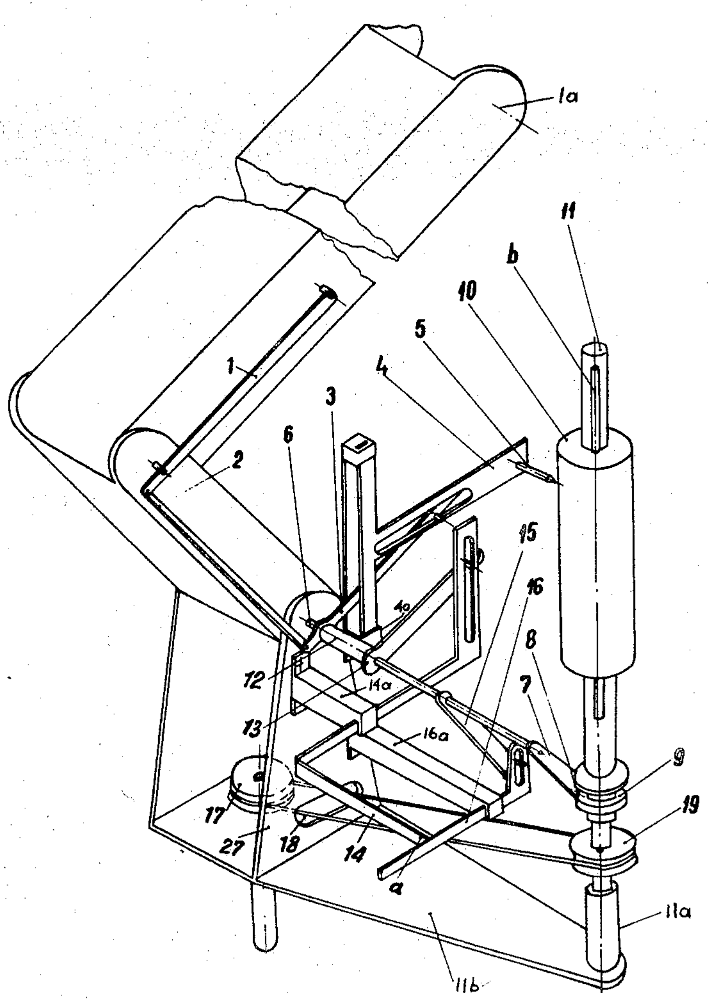
ABSTRACT: A device for indicating and/or transmitting information relating to the position of the top end of an articulated boom of a hydraulically operated crane having a base which is rotatably mounted about a vertical axis. A lower boom pivotally connected to the base and an upper boom pivotally connected to the lower boom. Both the lower and upper booms being movable in the same vertical plane. A shaft axially extending from the pivotal connection between the base and the lower boom. Two pairs of levers mounted on the shaft; in each pair of levers one lever is parallel to either the upper or lower boom. Two slide mechanisms are operatively connected to one lever of each pair of levers and are adapted to respectively record the resultant horizontal and vertical motions of the upper and lower booms.



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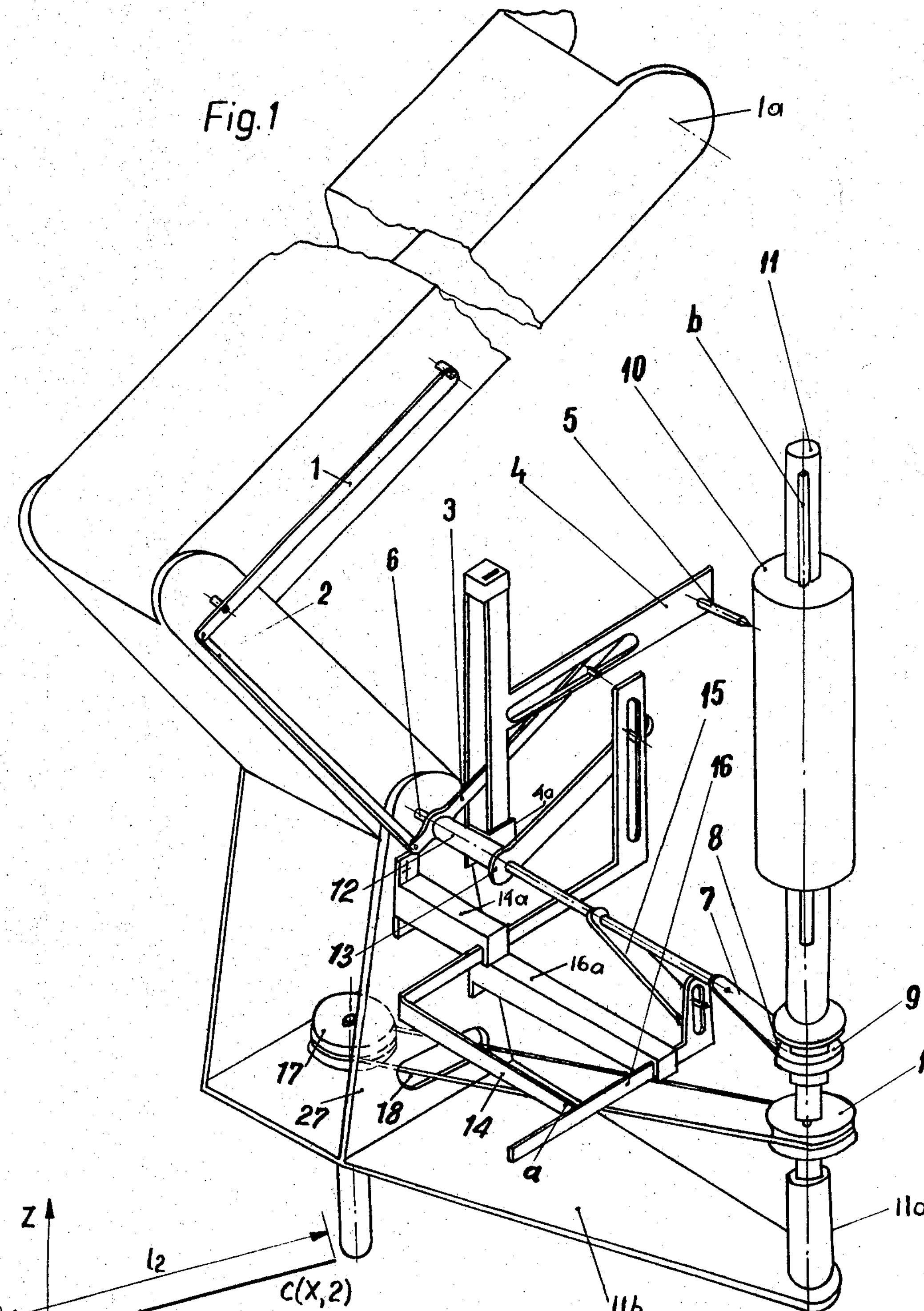

Fig.1

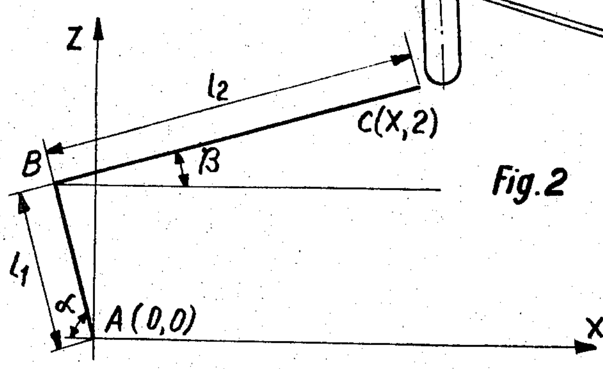

Fig.2

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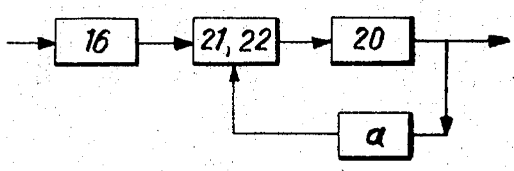

Fig. 4

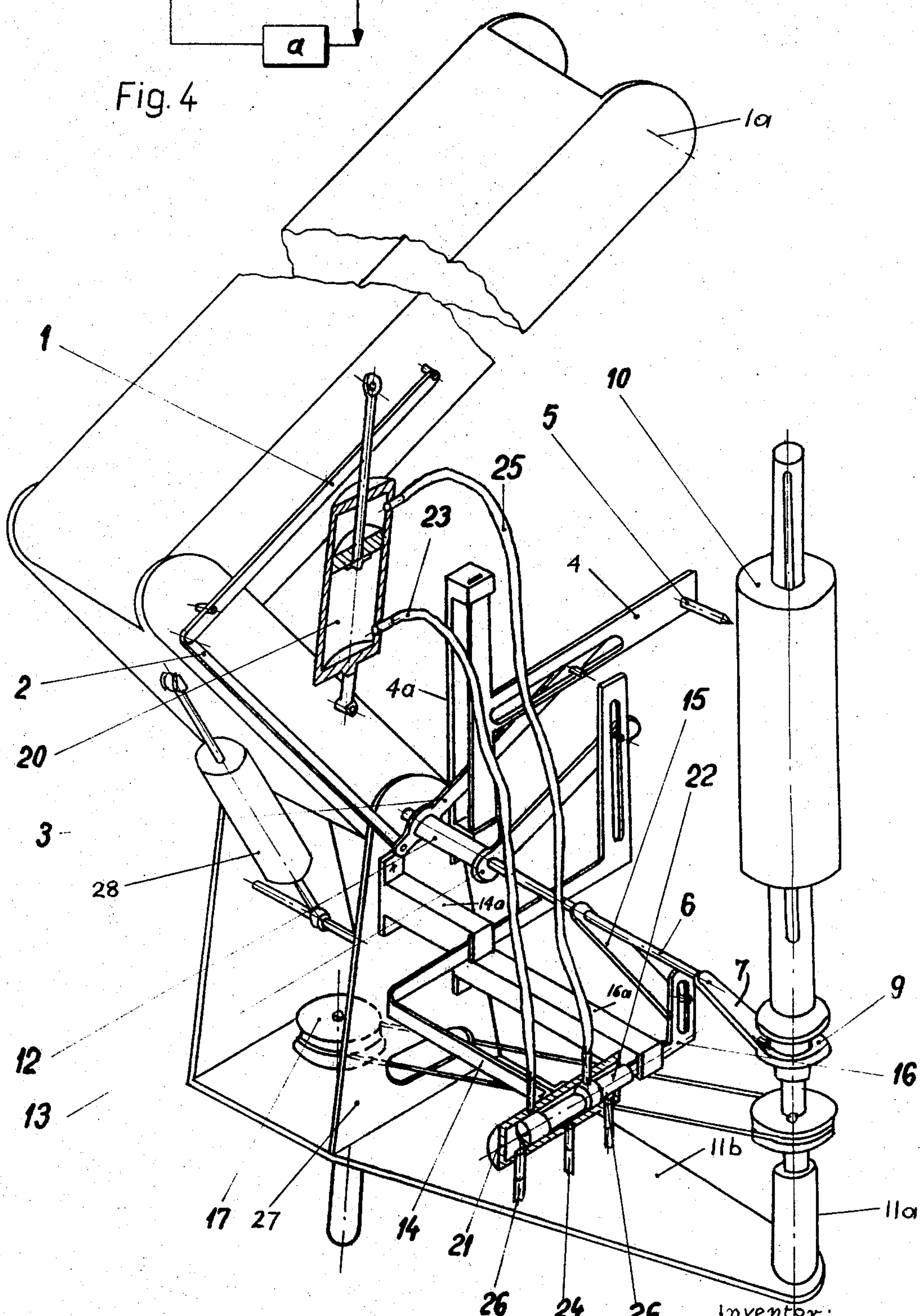

Fig. 3

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DEVICE FOR INDICATING THE POSITION OF THE PLATFORM OF CRANES WITH ARTICULATED BOOMS, ESPECIALLY CAMERA CRANES

The present invention relates to a mechanical device that indicates continually the position of the platform of cranes with articulated booms, more especially of camera cranes by means of a coordinate indicating system. The position of the crane platform is indicated in terms of the separate movements, in the same plane, of the individual booms. In this way the trajectory traversed by the crane platform is illustrated on a rotating cylinder.

Another and particularly important object of the present invention is to provide a hydraulic servomechanism which serves to produce rectilinear movements of the crane platform.

Devices are known which cooperate only with a single boom and indicate only the height of the camera platform and the angle of rotation of the boom relative to its vertical axis. Also there are known devices for lifting cargo that indicate, in terms of the boom inclination i.e. of the cargo lever, the maximum load that can be lifted by the crane.

Devices like those mentioned above may not, however, be used with cranes having articulated booms for indicating the coordinates of the position of the platform, because said coordinates do not result from a simple movement, but from the composition of the movements of both booms.

Electric devices are also known that compute the spatial coordinates of a point situated at the end of two links pivotally connected to each other and movable in space, said computation being performed by vectorially adding the link movements in terms of the link lengths and of the link inclinations relative to a given coordinate system. Such devices are, however, used for controlling some machine tools according to a given program and they are complicated and necessitate a separate power source.

The device according to the invention eliminates these disadvantages by decomposing the movements of the two booms, in the vertical plane containing them, by means of slide mechanisms into vertical and horizontal linear components; the vertical components being added separately, and the horizontal components also being added separately, said mechanisms being designed so that these sums represent at a certain scale the crane platform coordinates relative to a given coordinate system, more particularly the platform ordinate and abscissa.

In order to make possible crane movements only in one plane, i.e. to maintain in the platform ordinate or abscissa constant during the movement, the camera crane of this invention is provided with booms that are driven by well-known hydraulic cylinders. These cylinders are controlled by a hydraulic servomechanism in such a way that the indicator of the coordinate which is perpendicular to the plane containing the movement remains fixed relative to the component on which the respective coordinate is measured in the indicating device.

In order to indicate the height of the camera platform, the movement of the upper boom is transmitted by means of a parallelogram mechanism, consisting of three levers, to a slide provided with an indicator, while the movement of the lower boom is transmitted by means of a shaft mounted in the lower articulation of said boom to a lever and a pin engaging the groove of a cylinder, so that said lever moves the cylinder along a vertical axis in such a way that the distance between the final position of the indicator and a zero mark on the cylinder is proportional to the change in height of the crane platform.

For the indication of the abscissa of the crane platform, the movement of the upper boom is transmitted by means of the same parallelogram mechanism consisting of three links and a shaft, to a lever which by means of a slide mechanism drives an indicator, while the movement of the lower boom is transmitted by means of a shaft fixed in the lower articulation of the lower boom, to a lever which by means of a slide mechanism drives a rule in such a way that the distance between the final position of the indicator and a zero mark on the rule is proportional to the change in the abscissa of the crane platform.

For the indication of the angular position of the vertical plane containing the crane booms, relative to an initial vertical plane, the crane rotation is transmitted by means of a belt from a pulley situated in the vertical axis of the crane and fixed relative to the initial vertical plane, to a second pulley coaxial with the cylinder of the height indicating mechanism, said second pulley being able to turn said cylinder, so that the angle of rotation of the cylinder corresponds to the angle of rotation of the crane.

In order to make the invention more clearly understood, reference will be made to the accompanying drawing which is given by way of example and in which:

FIG. 1 is an isometric schematic view of the device of this invention;

FIG. 2 is a vector diagram which indicates the mathematical principle of the device;

FIG. 3 is an isometric schematic view of the hydraulic servomechanism designed only for producing vertical movements of the crane platform; and

FIG. 4 is a block diagram of the servomechanism illustrated in FIG. 3.

For the indication of the height of the crane platform, the device according to the invention is provided with a parallelogram mechanism consisting of three links **1**, **2**, **3**, link **1** being fixed to the upper boom of a crane in such a way that link **3** is parallel to said upper boom as illustrated in FIGS. **1** and **3**. At its free end the link **3** drives by means of a slide mechanism a component **4** which is slidably mounted in a support member **4*a*** and which is provided with an indicator **5**. The support member **4*a*** is firmly connected to the crane pedestal member **27**. The component **4** is mounted in such a way that the vertical movements of the indicator **5** correspond to the vertical movements of the crane platform (not illustrated), which is operatively connected to the upper end **1*a*** of the upper boom caused by the upper boom movements. In the lower articulation of the lower boom there is coaxially mounted a shaft **6** fixed to the lower boom. On the shaft **6** there is fixedly secured a lever **7** parallel to the lower boom and provided with a pin **8** that engages a disc having a groove **9**, said disc being coaxially secured on the cylinder **10**. The cylinder **10** is slidably moving up and down a vertical shaft **11**, being driven by the pin **8**. The vertical movements of the cylinder **10** correspond to the vertical movements of the crane platform caused by the movements of the lower boom. The shaft **11** is slidably and rotatably supported in a bearing support **11*a***. The bearing support **11*a*** is mounted on a plate **116** extending from the crane pedestal.

During the operation of the device, if the lower boom has turned up with an angle α relative to the horizontal, and if the radius of the lever **7** is equal to r_1, the cylinder **10** reaches the height $Z_1=r_1\sin\alpha$. Similarly, if the upper boom has turned up with an angle β relative to the horizontal, and if the radius of the lever **3** is equal to r_2, the indicator **5** reaches the height $Z_2=r_2\sin\beta$. Between the indicator **5** and a zero mark taken as origin on the cylinder **10** appears a distance

$$\Delta Z=Z_2-Z_1=r\sin\beta+r_1\sin\alpha$$

If the length of the lower boom is l_1, and if the length of the upper boom is l_2, the angles α and β being the same as above, from FIG. 2 follows that the height of the crane platform is

$$\Delta Z=l_1\sin\alpha+l_2\sin\beta.$$

If between the lengths of the crane booms and those of the levers **3** and **7** exists the proportionality

$$\frac{r_1}{l_1}=\frac{r_2}{l_2}=\frac{1}{i}$$

than the distance ΔZ defined as above and the reading on the cylinder **10** represents at a scale $1i$ the height Z of the crane platform.

For the indication of the abscissa of the position of the crane platform use is made of the same parallelogram mechanism consisting of the links **1**, **2**, **3**, the link **3** being fixed on one end of a hollow shaft **12** which rotates freely on the shaft **6**. On the other end of the shaft **12** there is fixed a lever **13**, parallel to the upper boom, said lever driving at its free end, by means of a slide mechanism, a rod **14** provided with an indicator *a*. The rod **14** is slidably supported in a support member **14***a*, which is connected to the crane pedestal member **27**. The horizontal movements of the indicator *a* correspond to the horizontal movements of the crane platform caused by the movements of the upper boom. On the shaft **6** there is fixed a lever **15**, parallel to the lower boom and driving by means of a slide mechanism a ruler **16** which is slidably supported on a support member **16***a*, which is connected to the crane pedestal member **27**. The horizontal movements of the ruler **16** correspond to the horizontal movements of the crane platform caused by the movements of the lower boom.

During the operation, if the angle α is the same as before mentioned and if the radius of the lever **15** is equal to r_3, the abscissa change of the end of the lever **15** is $X_1 = r_3 \cos\alpha$. Similarly, if the angle β is the same as above and if the radius of the lever **13** is equal to r_4, the indicator *a* changes the abscissa X_2-r_4a and a zero mark taken as origin on the rule **16** appears a distance

$$\Delta X = X_2 - X_1 = r_4 \cos\beta - r_3 \cos\alpha$$

With the same notations as in FIG. **2** the net change in the abscissa of the crane platform is

$$X = l_2 \cos\beta - l_1 \cos\alpha.$$

If between the lengths of the camera booms and those of the levers **13** and **15** exists the proportionality

$$\frac{r_3}{l_1} = \frac{r_4}{l_2} = \frac{1}{k}$$

then the distance ΔX defined as above and read on the rule **16** represents at scale $1/k$ the change in height X of the crane platform.

In order to indicate the rotation of the vertical plane containing the crane booms, relative to an initial vertical plane, there is axially in the crane pedestal, and fixed relative to the initial vertical plane, a pulley **17** connected by means of a belt **18** to another pulley **19** which is coaxially mounted on the shaft **11**. By means of a sliding key (not illustrated) which is engaged in a key groove *b* of the shaft **11**, the pulley **19** rotates the cylinder **10**, said cylinder being able to move at the same time up and down in the bearing support **11***a*. If the pulleys **17** and **19** are of the same diameter, then the angle of rotation of the cylinder **10** read against the height indicator **5** is equal to the angle of rotation of the crane relative to the given initial plane.

An alternate embodiment of the invention is illustrated in FIG. **3** for effecting a movement of the crane platform only in the vertical plane. The upper boom of the crane is driven by a hydraulic cylinder **20** controlled by means of a hydraulic valve **21** and a spool **22**. The valve is moved by the rod **14**, and the spool by the ruler **16**. With this arrangement, if the cylinder **28** for actuating the lower boom is controlled directly, the cylinder **20** for actuating the upper boom follows the movement of the lower boom in such a way that the position of the rod **14** remains unchanged relative to the ruler **16**.

Assuming that the hydraulic cylinder for the lower boom is controlled in such a way that the lower boom moves upwards from the horizontal, the crane platform moves rightwards. The ruler **16** translates mechanically this movement into a leftward movement of the spool **22**. Then, by means of a conduit **23**, the lower chamber of the cylinder **20** is connected with a pressure conduit **24**, while the upper chamber is connected through a conduit **25** to a return conduit **26**. It follows that the upper boom will be lifted, moving thus leftwards the crane platform. The rod **14** will translate mechanically this movement into a leftward movement of the valve **21**, until the communications with the conduits **23** and **25** are again closed. Thus the servomechanism controls the upper boom movements in such a way that any movement of the rod **14**, with its indicator *a*, relative to the ruler **16** is canceled, i.e. any deviation of the crane platform movement from a strictly vertical movement, deviation caused by the movement of the lower boom, is canceled by the movement of the upper boom end the crane platform travels only vertically. This movement is read against the indicator **5**, on the cylinder **10**.

One suitable arrangement of the input, output and feedback signals of the above system is identified in FIG. **4**. As it may be seen the movements of the lower boom are controlled directly, i.e. by an open loop, and are translated by means of the ruler **16** into an input signal for the valve **21** and the spool **22** controlling the hydraulic cylinder **20**. The movements imparted by this hydraulic cylinder to the upper boom are translated by the indicator *a* into a feedback signal for the valve **21** and its spool **22**.

In order to obtain movements of the crane platform only in a horizontal plane, use is made of a similar servomechanism (not illustrated), the valve **21** being however put into movement by the indicator **5**, and the spool **22** by the cylinder **10**.

A servomechanism like that described above may control movements of the crane platform also in other planes, if the indicator device is so designed that it decomposes the movements of the two booms according to a suitably chosen coordinate system.

In order to obtain the same results, i.e. movements of the crane platform only in one plane, use may be made also of servomechanisms in which the indicator device drives the hydraulic valve and its spool by means of differential levers.

Also, the characteristics of the system may be improved if besides the projections of the two boom movements as input and feedback signals there is also made use of the derivatives relative to the time of the above-mentioned projections, i.e. the projections of the velocities and of the accelerations of the two boom movements. The velocities may be obtained for example by means of centrifugal tachometers or of tachometric generators driven by the indicators described above, through multiplying gears. Similarly, the accelerations may be obtained by means of accelerometers. The output signals of the velocity and acceleration transducers may be used as inputs for separate hydraulic valves whose outflow is superimposed on that of the valve controlled by the indicator device. Alternately, the outputs of the various transducers may be superimposed electrically and used as inputs for an electromagnetic valve.

The device according to the invention presents the following advantages:

- it indicates both the movements of each separate boom and the resultant of their movements;
- it makes possible to follow the movements of the booms in comparison with the crane rotation;
- It makes possible to traverse in a certain part of the space any given trajectory, more especially with camera cranes;
- it is capable of indicating the load deflections in order to establish the maximum permissible load with cranes having articulated booms;
- it makes possible the immediate determination of the height of a platform lifted by a crane having an articulated boom; and
- it makes possible rectilinear movements of the platform of cranes having articulated booms, more especially camera cranes.

Although my invention has been illustrated and described with reference to the preferred embodiments thereof, I wish to have it understood that it is in no way limited to the details of such embodiments but is capable of numerous modifications within the scope of the appended claims.

I claim:

1. In a device for indicating information relating to the position of the top end of an articulated boom mechanism having a

base which is rotatably mounted about a vertical axis, comprising in combination:

a lower boom member being pivotally connected at one of its ends to said base;

an upper boom member pivotally connected to said lower boom member of the other end thereof;

a shaft axially extending from the pivotal connection between said lower boom member and said base;

a sleeve coaxially and rotatably mounted over said shaft;

a first pair of levers fixedly secured to said sleeve so as to rotate jointly therewith, said first pair of levers being parallel to said upper boom member during their respective movement;

a second pair of levers fixedly secured to said shaft so as to rotate jointly therewith, said second pair of levers being parallel to said lower boom member;

an indicating cylinder rotatably mounted about a vertical axis and being reciprocally movably mounted along said vertical axis, said cylinder having annular groove means;

one lever of said second pair of levers having a projecting pin which extends into said annular groove means so that when said one lever rotates it moves said indicating cylinder along its vertical axis a distance which is proportional to the vertical distance traversed by said lower boom member when it pivots about said base;

first slide means operatively connected to said other lever of said second pair of levers; said other lever moving said first slide means horizontally a distance which is proportional to the horizontal distance traversed by said lower boom member when it pivots about said base;

second slide means operatively connected to one of said levers of said first pair of levers, said one lever moving said second slide means horizontally a distance which is proportional to the horizontal distance traversed by said upper boom member when it pivots about said lower boom member; and

third slide means operatively connected to said other lever of said first pair of levers, said other lever moving said third slide means vertically a distance which is proportional to the vertical distance traversed by said upper boom member when it pivots about said lower boom member.

2. In the device for indicating information as set forth in claim **1** and wherein the length of one lever in said first and second pairs of levers is respectively proportional to the length of said upper boom member and the length of the other lever in said first and second pairs of levers is proportional to said lower boom member.

3. In the device for indicating information as set forth in claim **2** and wherein said second slide means includes first indicating means adapted to cooperate with said first slide means so as to indicate the resultant combined horizontal movement of said upper and lower boom members.

4. In the device for indicating information as set forth in claim **2** and wherein said third slide means includes second indicating means adapted to cooperate with said indicating cylinder so as to indicate thereon the resultant combined vertical movement of said upper and lower boom members.

5. In the device for indicating information as set forth in claim **2** and wherein a pulley operatively connects said indicating cylinder to said base in a manner which causes said cylinder and base to rotate equiangularly.

6. In the device for indicating information as set forth in claim **5** and wherein:

first hydraulic actuating cylinder means are pivotally connected to said upper boom member at one of their ends and to said lower boom member at the other end;

hydraulic fluid cylinder distributing means fixedly secured to said second slide means so as to move horizontally jointly therewith;

a fluid distributing piston slidably disposed in said hydraulic fluid cylinder means, said piston being fixedly secured to said first slide means so as to move jointly therewith;

first hydraulic inlet and outlet conduit means operatively connecting said hydraulic fluid cylinder to said first hydraulic actuating cylinder; and

second hydraulic inlet and outlet conduit means operatively connecting said hydraulic fluid cylinder distributing means to a source of hydraulic power; said hydraulic fluid cylinder distributing means and said piston slidably disposed therein being constructed and arranged so that said first hydraulic cylinder means is only hydraulically energized via said hydraulic fluid cylinder distributing means when the horizontal movements of said upper and lower boom members are not equal in sign and opposite in direction.

7. In the device for indicating information as set forth in claim **6** and wherein second hydraulic actuating cylinder means are pivotally connected to said lower boom member for pivotally moving it with respect to said base.