June 9, 1942. V. A. NICOLESCU 2,286,153

WALKING BEAM MECHANISM

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Fig. 1

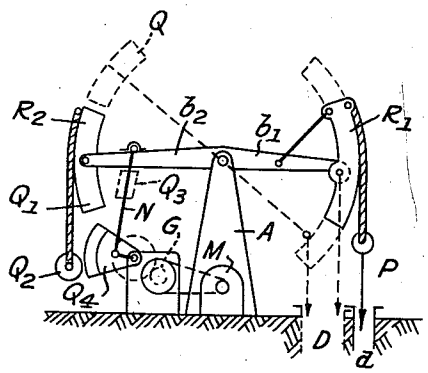


Fig. 2

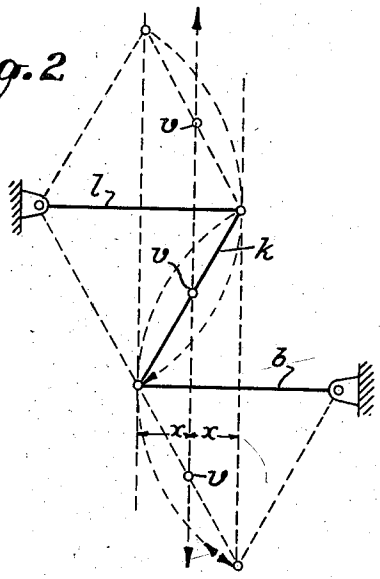


Fig. 4

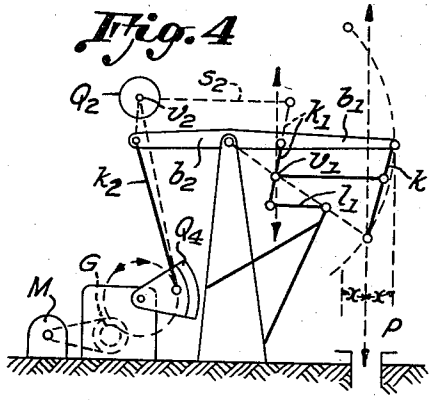


Fig. 3

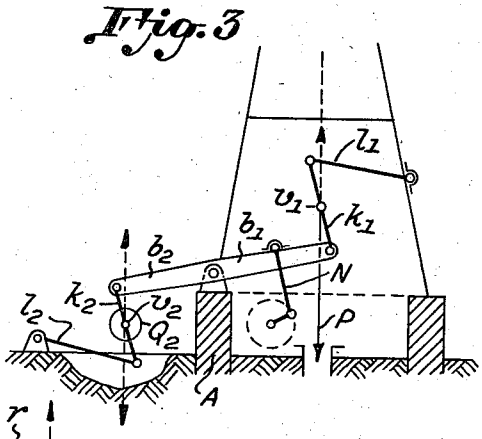
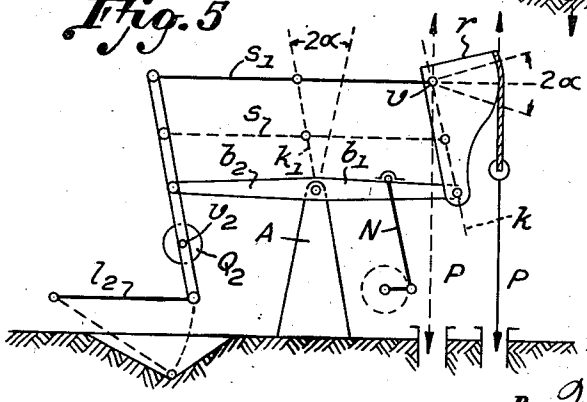


Fig. 5



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Fig. 6

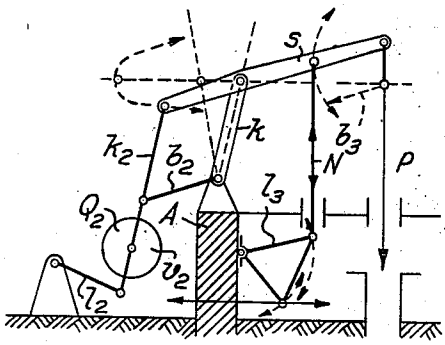


Fig. 7

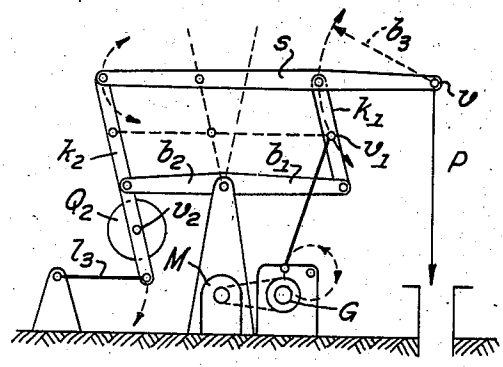


Fig. 8

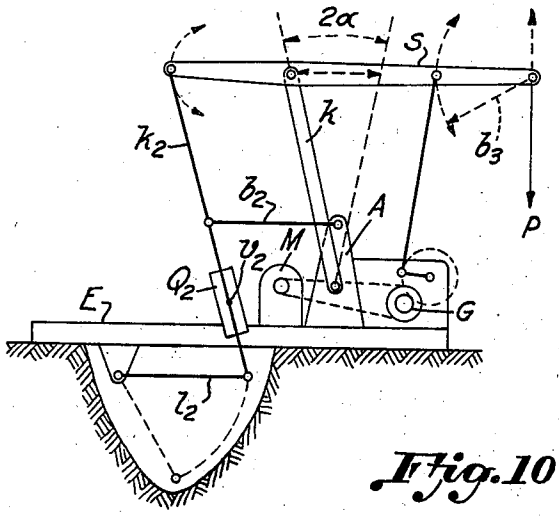


Fig. 9

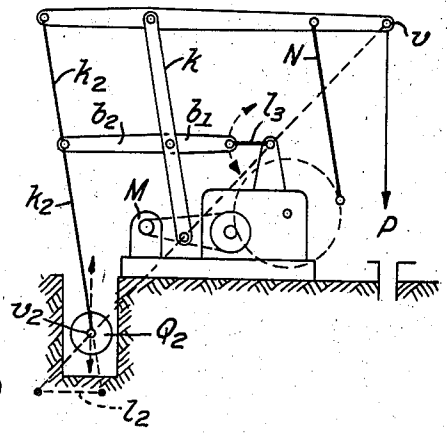
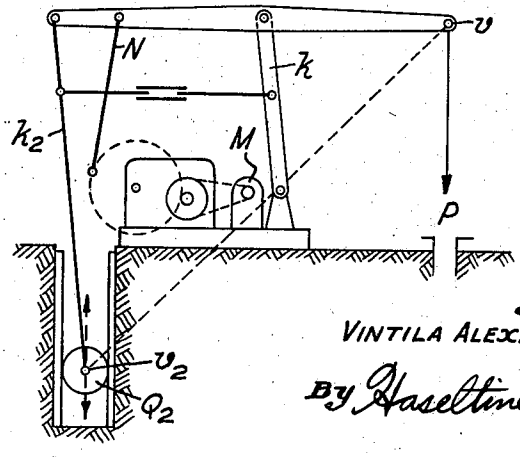


Fig. 10



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UNITED STATES PATENT OFFICE

2,286,153

WALKING BEAM MECHANISM

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Application August 6, 1938, Serial No. 223,432
In Germany August 9, 1937

14 Claims. (Cl. 74—41)

In quite a number of engines the adherence to a rectilinear motion is a sine qua non for satisfactory working. Engines, wherein the working stroke is controlled by means of a working-beam and in which it is not possible to make use of a cross-head, always suffer from the drawback that the oscillatory motion which is carried out by the working-beam and which causes the ends of the beam sections to move upon arcs of a circle, was hitherto capable of being converted into an at least approximately rectilinear motion only by means of complicated special arrangements. One of the auxiliary measures known for this purpose consists in designing the ends of the working beam sections in the form of a "horse's head," this term in certain branches of the art denoting a segment the centre of curvature of which coincides with the centre of gravity of the working beam. Now, these special constructions of segments on the working beam represent a heavy load and require much space. In addition, they can be used only when the working beam carries out only relatively small oscillatory motions, that is to say when the strokes are relatively small.

Especially in the case of engines whose efficiency increases as the stroke increases, such, for example, as the pumps working in bore-holes for conveying the oil and the petroleum, no useful results can therefore be obtained with these known arrangements without imparting colossal dimensions to the working beam and to the necessary super-structure therefor. As, however, the swinging moment increases in each case where the dimensions are increased so that the dead-weight of the segments is greater, it is impossible to keep such engines working for days and weeks, as they must do for example when working on the so-called "bores," without thereby damaging the super-structure and the lifting rods.

It is precisely in the case of such bores, which serve the purpose of pumping the oil to the surface when the gas pressure in the oil stratum diminishes, that such drawbacks are very considerable. It has been recognized that such bores work better the larger the stroke of the pump piston but that hitherto the imperfection of the working beam and the superstructure attached thereto imposed a limit upon the increase of the stroke and thus also on the output of the pump. In these bores which sometimes extend to a depth of over 2000 metres it is of the greatest importance that both the lifting rods, as well as the counterweight and in some cases also the driving connecting rod, should have their motion confined to a substantially rectilinear path.

That which as explained above is particularly important in the case of bores in the oil industry, also has a general importance in the case of speed and power transmitters, which transmit the energy of crank or cam drives to the valves or pistons of engines; considering that in the case of a working beam the latter itself carries out one oscillation while its supports carry out two oscillations, it is in this way possible to effect a particularly suitable transmission, preferably having a ratio of 1:2 which in the case of various engines, especially in four-stroke engines, is very desirable.

According to the invention, the problem of converting rotary paths into rectilinear paths and vice versa by means of a system of links is solved by utilizing the lemniscate linkage system and parallelograms, well-known per se in kinematics the known principle being used that when two rods both articulated at one of their ends and both connected to a beam, are pivoted through equal angles, a certain point along the connecting beam will be displaced in a rectilinear path.

According to the invention use is made of this kinematic principle in that the connection to the working beam of the working appliances, which are to be guided in a rectilinear path—for example the lifting rods, the counter-weight and if necessary one point of the connecting rod—is effected by means of pendant, upright or supporting rods, which are so interconnected by means of links and connecting rods that the action of a lemniscate linkage system is produced and in that the working appliances are connected to the lemniscate system at the point in the said system which moves in a rectilinear path, parallelograms being interposed if necessary. In this manner it is possible, and this is of decisive importance in practice, to move a plurality of points simultaneously in rectilinear paths or vice-versa in predetermined curvilinear paths.

This inventive idea is realised in several embodiments hereinafter described in detail.

On the drawings Figure 1 illustrates a linkage system such as hitherto used when making bores.

Figure 2 illustrates the kinematic principle of which use is made according to the invention.

The further Figures 3 to 9 represent constructional forms of the fundamental inventive idea illustrated in Figure 2, being shown diagrammatically as applied to bore pump drives; the invention is however, not limited to such engines,

Figure 1 shows diagrammatically a side view of the hitherto usual construction of a pump gear, for example for oil bores, having a working beam b_1 b_2, mounted on the supporting bracket A and provided at both ends with horse-head-like segments R_1, R_2. Now, were the lifting rods P not to act upon the outside of the horsehead R_1 as shown in full lines, but direct upon the end of the working beam, it would be necessary to make the hole D very large, otherwise the rods would cant at the upper edge of the hole and render the work impossible to carry out, especially when the bores were very deep and the hole d very narrow. In order to make it possible to work in a narrow borehole, it has for a long time been necessary to make use of the horsehead-like segments. The mass of the horsehead R, and the space it would occupy when large lifts are required such as are desirable in such borings can easily be gathered from the drawing. In order that the counterweight Q_2 can also be guided as far as possible along a rectilinear path and in order in this way to eliminate the possibility of acceleration moments occurring during the oscillation of the working beam and thus acting upon the supporting bracket A, this end of the beam has been provided with a horsehead-like segment R_2, having the counterweight Q_2 suspended therefrom. The driving of the working beam is then effected in the usual manner from the engine M via a transmission gear G and a cranked push-rod N. Not only the mass Q_1 of the horsehead R_2 and the suspended weight Q_2, which latter is guided along a rectilinear path, but also a pivoted weight Q_3 mounted upon the cranked push-rod N, and a weight Q_4 attached to the end of the crank disc and rotating with the crank, will then all act as counterweight. These four different weights act in different ways and mutually supplement each other in that they must counterbalance the weight of the pump rods which constantly varies with the working conditions, and also the weight of the column of liquid. For this reason provision must as far as possible be made for the easy and sure manipulation in changing the balancing weights so as to suit the tractive forces acting upon the pump rods, such change being necessary more often.

First and foremost it is necessary to carry out longer strokes and at the same time to be sure that the lifting rods are constantly guided in a rectilinear path, and secondly to ensure that despite the increased stroke the counterweight is also constantly guided in a rectilinear path and so arranged as to be easily changed at an accessible point, and for this purpose use is now made of the kinematic principle diagrammatically illustrated in Figure 2.

The system of control rods used for this purpose is the limniscate linkage system known in kinematics, and which consists of two rods l and b and of a coupling rod k connecting the ends of the said two rods. When the connecting points between the rods and the coupling rod are moved along arcs of a circle, there will be a point v on the coupling rod k which will always move in a rectilinear path.

Figure 3 illustrates the application of this kinematic principle in the simplest and most direct manner. At each end of the working beam sections b_1 and b_2 there is connected a coupling rod k_1, k_2 the other ends of which are in turn connected to a link rod l_1, l_2. These link rods are articulated about a suitable point located at any convenient spot on the superstructure. The system of rods constituted by the two link rods l_1, l_2 and the coupling rod k_1 connecting them form a lemniscate linkage system, the feature of which is that upon the coupling rod k_1 there is a point v_1 which during each oscillation of the working beam will always move in a rectilinear path. According to the invention the working appliances which are to be guided in a rectilinear path, such for example as the pump rods, are connected to this point v_1 and thus constantly guided in a rectilinear path. On the other side of the working beam there is produced another lemniscate linkage system consisting of the two link rods b_2 and l_2 and the coupling rod k_2 connecting them, and carrying a weight Q_2 at the point v_2 which is constantly guided in a rectilinear path. It will be seen from the illustration in the drawings that this weight Q_2 which serves the purpose of counteracting the tractive force acting upon the opposite section of the working beam, is arranged in close proximity to the floor, so that it can be easily, conveniently and safely changed and adapted to suit any working conditions. If necessary the floor may be scooped out below the coupling rod k_2 so as to provide room for the motion of the link rod l_2.

The constructional form illustrated in this figure is particularly suitable for bores for which the tower is erected upon concrete floats A. The working beam is driven in the usual manner by means of the crank indicated at N.

According to the constructional form illustrated in Figure 4 the point v which moves in a rectilinear path is located at the end of a coupling rod k. The rectilinear guiding of the point v is also in this case effected by means of a lemniscate linkage system b_1, l_1, k_1 which of course also possesses a point v_1 guided along a rectilinear path. A connecting rod s_1 is articulated to this point v_1 and forms a parallelogram together with the working beam section b_1 and the additional coupling rod k and the coupling rod k_1. This parallelogram thus transmits the rectilinear motion of the point v_1 to the point v, when these points v and v_1 are located upon a straight line passing through the points of articulation of the link rods b_1 and l_1.

The rectilinear guiding of the counterweight Q_2 can be effected by means of the lemniscate system b_1, k_1, l_1 according to the same rule, by using a parallelogram produced by connecting the coupling rod k_1 and the coupling rod k_2 to which the weight Q_2 is attached by means of a rod s_2.

In this case the working beam is driven by means of a crank drive provided with a rotating weight Q_4 which is supplemented by the suspended weight Q_2 moving in a rectilinear path.

The constructional form illustrated in Figure 5 represents an inversion of the previously explained embodiment, by reason of the fact that in this case the parallelogram is arranged above the working-beam. In this case the rectilinear guiding of the point v upon the upwardly directed leg or rod k is effected by the lemniscate linkage system b_2, k_2, l_2 which produces the rectilinear guiding of the point v_2 at which the weight Q_2 is suspended. Compared with the constructional forms hitherto described the lemniscate linkage system is disposed at the opposite side of the pivoting point of the work-beam and folds downwardly, by building up the parallelogram above the working-beam. In this case the coupling k can be designed as a horse's head r on a

smaller scale, from the curvature of which the pump rods are suspended. The reason why it has been purposely omitted to connect the working tool direct to the point v on the coupling k which is guided in a rectilinear path, is to have the pump rods at a greater distance from the end of the working beam and also so that the upper connecting rod s_1, which would otherwise be submitted to pressure, may be submitted to tractive forces only. Moreover, by using this horse head like segment r it is possible to vary the length and speed of the stroke of the pump rods, for during the first half of the oscillation of the working-beam the pump rods attain a greater stroke at an accelerated speed while during the second half of the said motion, there is a corresponding reduction and slowing down. The angles α and 2α shown in Figure 5 show the angles of oscillation of the respective parts of the rods. The connecting rod s_1 may be arranged at varying heights, and may for example take up the position s as shown in dotted lines.

Figure 6 shows a constructional form derived from the example shown in Figure 5 wherein the upper connecting rod s is designed as working-beam and the coupling rod k is connected to the pivoting point of the lower working-beam and used as a support for the upper working-beam. The advantage of this constructional form is in the first place that the working-beam is placed at a higher level, and carries the pump rods freely at its free end, and that the front section b_1 of the working-beam now being superfluous, can be eliminated, thus clearing the entire space above the bore hole for working. The drive of the upper working-beam is effected by means of the push rod N, which also in this case forms the coupling rod of a lemniscate linkage system the lind rod of which constitutes on the one hand the radius b_3 of oscillation of the point which moves in a circular path upon the working-beam s and on the other hand the rocker l_3, the oscillating motion of the push rod being thus much reduced, so that it is possible to work with a narrow passage through the platform.

The advantage of this design consists in that the oscillating support of the working-beam can be mounted direct upon the concrete block A and that the counterweight Q_2 works at a reasonable height above ground level.

Figure 7 shows an alternative form of the previous construction illustrated in Figures 5 and 6. In this case the lower working-beam b_1, b_2, is retained, while the upper connecting rail s is at the same time designed as an upper working-beam. The supporting of the upper working-beam s is effected by means of the support k_1 attached to the end b_1 of the shorter lower working-beam, the said support acting on the one hand as a link in the parallelogram and on the other hand as the coupling rod in the system consisting of b_1, the support k_1 and the front end b_3 of the upper working-beam s, the connecting rod N being attached to the point v_1 of the said system which is guided in a rectilinear path.

Figure 8 shows a further development of the example illustrated in Figure 6. This constructional form is arrived at by mounting the coupling rod k with its lower end further down upon the supporting bracket A than the connecting point of the link rod b_2, so that all the components necessary to drive this pump gear and to effect the control here described, as well as the motor M, the gearbox G and the link rod l_2 can be arranged upon one common horizontal frame plate E.

Finally a further development of the constructional form shown in Figure 8 is illustrated in Figures 9 and 10. This is arrived at by causing the control link rod l_2 to act, not on the lower end of the coupling rod k_2 but at a point upon the working beam section b_1, this point carrying out an identical motion, namely along the arc of a circle, so that when a further link rod l_3 is connected to the section b_1 the link rod l_2 may be omitted without thereby altering the motion of the remaining points or the nature of the system. Bearing in mind the explanation given above the method of working of the constructional forms shown by way of example in Figures 9 and 10 will be understood without difficulty.

As a general rule it can be accepted that in a lemniscate linkage system in which as has been shown, there are several points which travel along circular or rectilinear paths, any one of these points can be forced to retain its path of motion, so that the corresponding controlling link rod of the lemniscate system can be eliminated or removed whenever it is in the way, so that the erection of the system is facilitated.

In the same way it might be possible in many cases to force for example the point v_1 or v_2 of the system as in one of the Figures 4, 6, 7, 8, 9, 10 which moves in a rectilinear path, to move along a rectilinear path by any desired means—by a sliding block mechanism or other kinematic device—so that where this would lead to practical advantages the link rods l_2 or l_3 could be eliminated.

In both cases the remaining link rods, connecting rods, coupling rods, etc. of the lemniscate linkage system would remain, and their arrangement effects in the strict sense of the invention the correct conversion and transmission of rotary motion into rectilinear motion and vice versa.

Kinematically the points which describe rotary or rectilinear paths are easily found when it is considered that the points v, v_1, v_2 lie along the straight line connecting the point of suspension v—which is guided in a rectilinear path—of the working tool (pump rods) to the bearing point of the link rod l_2, or as the case may be l_3, in this manner also determining the length of the link rods l_2 and l_3 etc.

Any kinematic inaccuracies which may arise from the fact that the upper end of the connecting rod k which acts as an oscillating supporting frame for the working-beam, describes a short circular path instead of an exactly rectilinear path, can be sufficiently compensated for by suitably modifying the link rods to suit practical conditions.

What I claim and desire to secure by Letters Patent of the United States is:

1. A working-beam system for converting rotary motion into rectilinear motion and vice versa, comprising a straight balancing beam or link having a pivotal connection intermediate the ends thereof and a second pivotal connection upon one arm of the same to one side of the first pivotal connection, a second link connected to the second pivotal connection on said beam or link and having a pendent portion, a further link connected to a stationary pivot at one end and at the other end pivotally connected to said pendent portion, means for driving and thereby

moving said beam or link, and means connected to the end of the other arm of the latter adapted to communicate the resultant rectilinear motion of the system to a pump, piston or valve rod.

2. A system according to claim 1, in which the last mentioned means includes another link connected at one end to a second stationary pivot, and yet another link connected at one end to the other end of said other link and at its other end to the end of the other arm of the beam or link and having intermediate the ends thereof a connection for operating the pump, piston or valve rod.

3. A system according to claim 1, in which the last mentioned means includes a link member pivotally connected at one end to the end of the other arm of the beam or link, another link connected pivotally at one end to the link member and being substantially parallel to the beam, means connecting the other end of said other link to said beam so as to form a parallelogram structure therewith, and means on said link member forming a connection for connecting said link member with the pump, piston or valve stem.

4. A system according to claim 1, in which another link is connected to intermediate pivotal connection of the beam at one end of said other link, a stationary pivot in parallelism with the second link connected to the other end of the latter and having a further link connected pivotally thereto at one end and at the other end to an intermediate portion of the second link in parallelism with the beam.

5. A system according to claim 1, in which the second link projects upwardly above its pendant portion so as to terminate in a pivotal connection a further link connected pivotally to the end of the other arm of the beam in parallelism with the second link, and a relatively long link connected at one end and an intermediate portion to the upper ends of said second link and said further link in parallelism to said beam, said long link having an end projecting beyond the resulting parallelogram structure having a pivotal connection for connecting said long link with the pump piston or valve stem.

6. A system according to claim 1, in which a further link is connected at one end to the intermediate pivotal connection upon the beam and at the other end to a stationary pivot, in parallelism with the second link, a second stationary pivot disposed directly above the first mentioned pivot, an additional link connected at one end to said second pivot and at the other end to the second link in parallelism with the beam.

7. A system according to claim 1, in which a further link is connected at one end to the intermediate pivotal connection upon the beam, and at the other end connected to a stationary pivot, in parallelism with the second link, a further link member connected pivotally to an intermediate portion of said further link intermediate to same and at one end to an intermediate portion of the second link, while the other end carries a pivotally connected link, which in turn is connected to a second stationary pivot at a higher level than the first pivot and a counterpoise connected to the lower end of the pending portion of the second link to replace the link otherwise connected thereto.

8. A system according to claim 1, in which a further link is connected at one end to the intermediate connection upon the beam and at the other end to a stationary pivot in parallelism with the second link, a further link member connected at one end to an intermediate portion of said further link and to an intermediate portion of the second link in parallelism with the beam, said further link member being variable in length and the lower end of the pendant portion of the second link having a counterpoise replacing the link otherwise connected thereto.

9. A working beam system for rectilinearly operating depth pumps such as used for oil bore holes, comprising a link gear constituting an articulated lemniscate link system with the members thereof forming a parallelogram comprising four elongated members articulated together, of which one member on one side includes the balancing beam of the system or at least a portion of said beam and another member on another side includes a coupling bar in said system or at least an extension of said bar connected to one end of said beam, some of the members of said system having portions moving rectilinearly which in each case are connected pivotally to a point located on a straight line passing through the articulation points of said lemniscate system or at least the extension thereof and on one of the sides of the parallelogram or on the extension of the same side.

10. A working beam system according to claim 9, having the link system forming two adjacent parallelograms, the first being formed by a link or bar parallel to and disposed below the balancing beam and connected to an intermediate articulation point upon the coupling bar which moves rectilinearly in a vertical direction, another link parallel with the coupling bar and articulated to the same arm of the balancing beam to which said coupling bar is connected, said last mentioned link having its point of articulation with the first mentioned link or bar movable rectilinearly in a vertical direction and serving as the point of attachment for a pump rod, and the second parallelogram being formed by a further link parallel to and spaced for the most part above the second arm of the balancing beam, said further link being articulated at one end to the upper end of the link which is parallel to the coupling bar, and a link parallel to said last mentioned link articulated to the end of said second arm of the balancing beam and at its other or upper end being articulated to the other end of said further link and carrying a counterpoise weight.

11. A working beam system according to claim 9, with the link system forming the parallelogram including a link or bar parallel to and spaced above the balancing beam, another link articulated to a portion of said beam and extending upwardly in parallelism with the coupling bar and also articulated to the end of said link or bar, a portion in the link gear to which the drive may be applied, a portion at one end of said link or bar capable of moving rectilinearly in a vertical direction, and a downward extension upon the coupling bar having a portion below the connection thereof with the balancing beam carrying a counterpoise weight.

12. A working beam system according to claim 9, with the link system forming the parallelogram, having the coupling bar rockably mounted and pivotally supporting the balancing beam intermediate the ends thereof, and including a link member articulated to the lower end of said coupling bar at its pivotal mounting and extending in spaced parallelism beneath one end

of the balancing beam, a further link parallel with the coupling bar connecting said one end of the balancing beam to the outer end of said link member and having a portion extending below said outer end of the latter link member which is capable of moving rectilinearly in a vertical direction and carries a counterpoise weight, the other end of the balancing beam also being capable of moving rectilinearly in a vertical direction and adapted to be connected to a pump stem.

13. A working beam system according to claim 9, with the link system forming the parallelogram, having the coupling bar rockably mounted and pivotally supporting the balancing beam intermediate the ends thereof, and including a link member disposed in parallelism with the balancing beam and articulated intermediate its ends to said coupling bar, one end of said link member being adapted to have the drive for the system connected thereto, a further link parallel with the coupling bar having its upper end articulated to the other end of the balancing beam and a lower portion capable of moving rectilinearly in a vertical direction and carrying a counterpoise weight while an intermediate portion is articulated to the outer end of said link member, and a portion upon one end of said balancing beam also being capable of moving rectilinearly in a vertical path and having the stem of a pump connected thereto.

14. A working beam system according to claim 9, with the link system forming the parallelogram, having the coupling bar rockably mounted and pivotally supporting the balancing beam intermediate the ends thereof, and including a link member disposed in parallelism with the balancing beam beneath one end of the latter and having one end pivoted to a stationary support at a point spaced above the lower mounting of the coupling bar, a further link articulated at its upper end to said one end of the balancing beam and having a lower portion capable of moving rectilinearly in a vertical path and carrying a counterpoise weight, while at a point intermediate its ends said further link is articulated to the outer end of said link member, and a portion upon the other end of said balancing beam also capable of moving rectilinearly in a vertical path and being connected to a pump stem.

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