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Itazu

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[54] **EXTENDABLE MECHANISM**

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[51] **Int. Cl.** **B66f 3/00**

[58] **Field of Search** ..... 254/124, 126, 122, 93 H; 182/157, 158

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Primary Examiner—Othell M. Simpson
Assistant Examiner—Robert C. Watson
Attorney, Agent, or Firm—Saul Jecies

[57] **ABSTRACT**

An extendable mechanism is provided which may be freely designed in order to produce a force required for a given purpose of use. The mechanism generally comprises a pantograph or cross linkage, a pair of auxiliary links each of which is hinged to each of a pair of main links of the pantograph or cross linkage at a point between the pin joints of each link, and an extending device such as a hydraulic jack which is interposed of the pin joint between said pair of links and the joint of the pair of auxiliary links.

6 Claims, 7 Drawing Figures

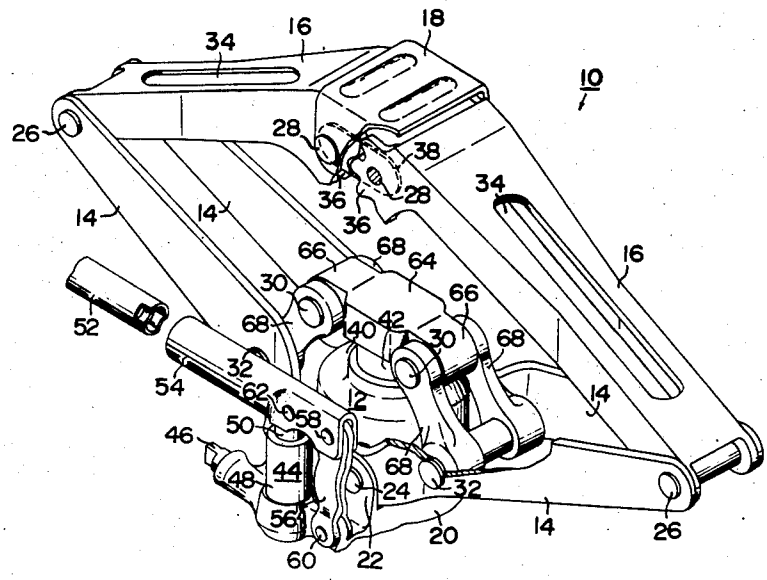
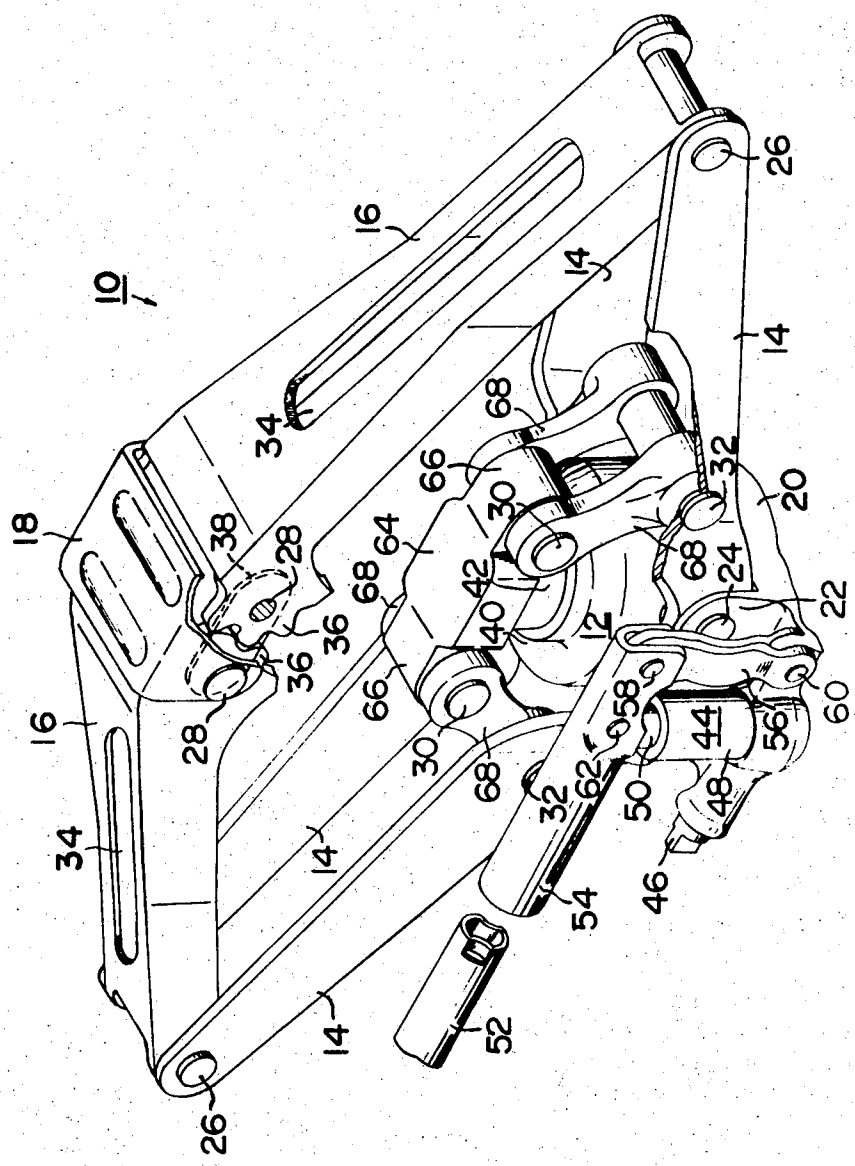


FIG. 1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12
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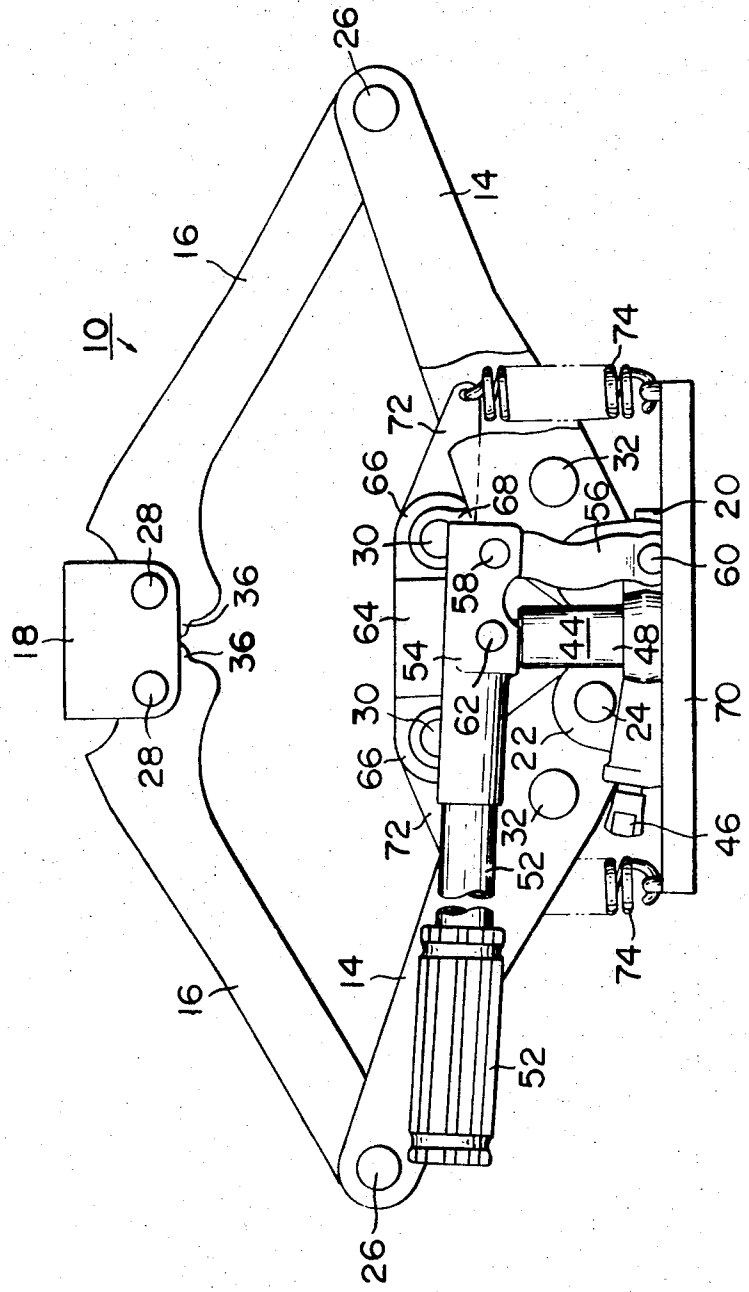
62
64
66
68

FIG. 2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26
14
16
74
72
66
68
32
56
20
60
30
58
64
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62
44
48
24
70
22
46
52
18
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36
74
16
14
52
26

FIG. 3

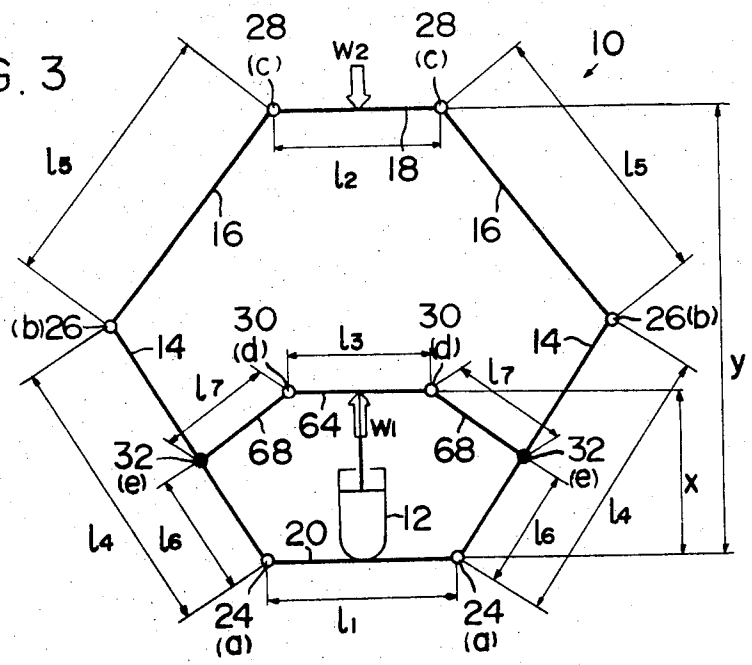

28
(c)
W2
28
(c)
10
l5
l5
l2
18
16
16
(b)26
30
(d)
l3
30
(d)
26(b)
14
14
l7
l7
y
64
W1
68
68
32
(e)
32
(e)
x
l4
l6
20
12
l6
l4
24
(a)
l1
24
(a)

FIG. 4

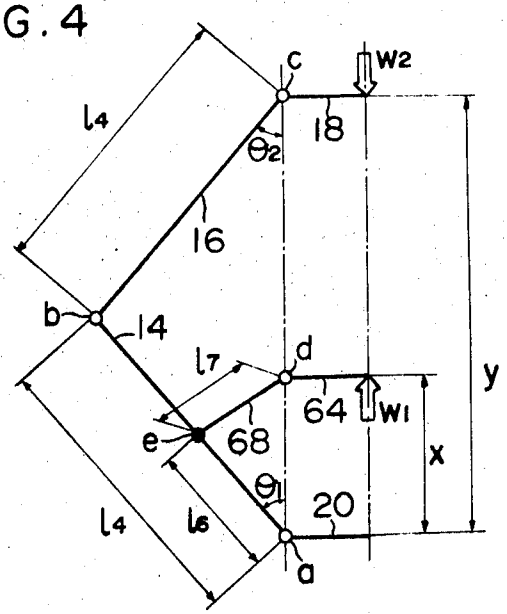

c
W2
l4
18
θ2
16
b
14
d
l7
y
64
W1
e
68
x
θ1
20
l4
l6
a

FIG. 5

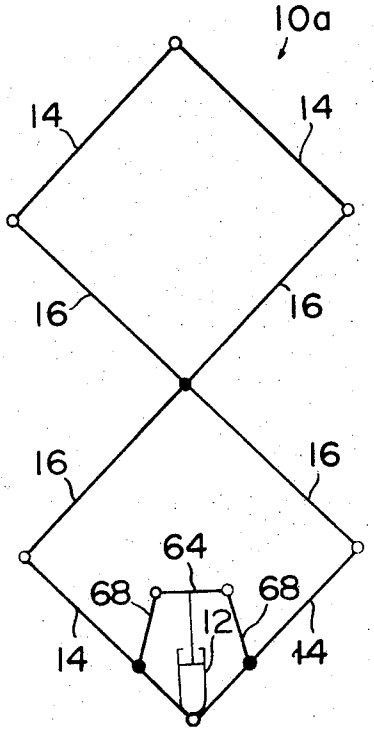


FIG. 6

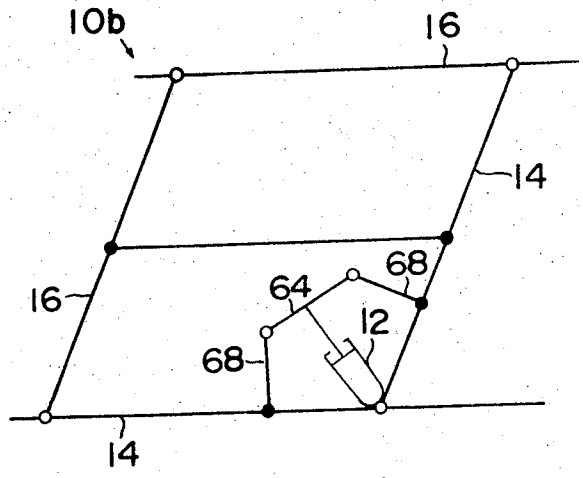
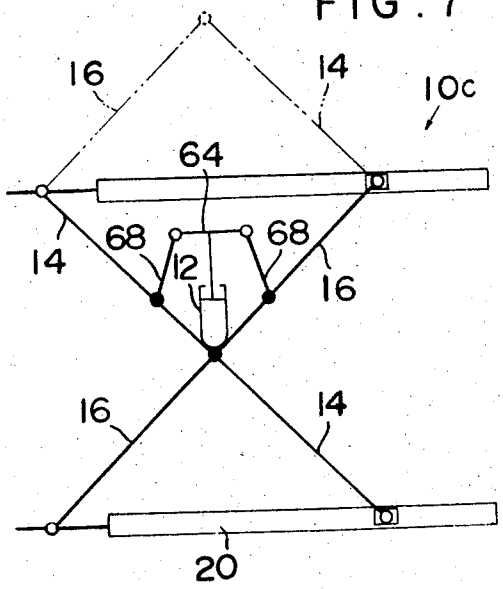


FIG. 7



EXTENDABLE MECHANISM

BACKGROUND OF THE INVENTION

The present invention relates generally to an extendable mechanism using a pantograph or cross linkage, and more particularly to an extendable mechanism best adapted for use as a lift.

Pantograph jacks and table lifters are typical lift devices using a pantograph or cross linkage. A pantograph jack generally comprises a pantograph linkage and a screw threaded to the opposed joints of the linkage. The spacing between the opposed joints may be increased or decreased by turning the screw. A table lifter generally comprises a base and a table coupled to each other by a parallel or cross linkage. The table is lifted by a hydraulic hoist interposed between the base and the linkage. In both the pantograph jack and table lifter the maximum force required when the jack or lifter starts to lift because of their mechanisms. The lifting force is gradually decreased as the jack or table lifter is lifted. The lift speed is also fastest when the jack or table starts to lift and is gradually decreased as the jack or table is lifted. Thus the lifting force and the lift speed cannot be freely selected depending upon the purpose of use, so that the design for the conventional pantograph jacks and table lifters are extremely difficult.

SUMMARY OF THE INVENTION

One of the objects of the present invention is therefore to provide an improved extendable mechanism, using a pantograph or cross linkage which may be freely designed in order to provide any desired extending or lift force and speed or lift speed. Briefly described, according to the present invention a pair of auxiliary links are hinged to a pair of main links of a pantograph or cross linkage at a suitable point between the two pin joints of each link, and an extending device such as a hydraulic jack is interposed between the pin joint of the pair of auxiliary links and the pin joint between said pair of main links. The extending or lifting force as well as the extending or lift speed may be freely selected over the full lift stroke by selecting the point at which the pair of auxiliary main links are hinged to the pair of links.

The above and other objects, features and advantages of the present invention will become more apparent from the following description of some preferred embodiments thereof.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a perspective view of a pantograph jack embodying the present invention;

FIG. 2 is a front view of a variation thereof having a pair of return springs;

FIGS. 3 and 4 are diagrammatic views used for the explanation of the principle of the pantograph jack shown in FIG. 1; and

FIGS. 5, 6 and 7 are diagrammatic views of various linkages embodying the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 illustrates a pantograph jack **10** embodying the present invention, but it will be understood that the present invention may be also applied to various linkages. The pantograph jack **10** generally comprises a hydraulic jack **12**, which also serves as a base, a pair of lower links **14**, a pair of upper links **16** and a saddle **18** for receiving a load.

A pair of flanges **22** are formed at both sides of a seat **20** of the hydraulic jack **12** in opposed relation. Each of the lower links **14** comprises a pair of steel plates or the like whose lower ends are rotatably pivoted to the flanges **22** with pins **24**. Each of the upper links **16** comprises a channel-shaped steel member whose lower end is hinged to the upper end of the lower link **14** with a pin **26**. An elongated slot **34** is formed in the base of each channel-shaped upper link **16** in order to reduce the weight. The upper ends of the pair of upper links **16** are rotatably coupled to each other through the saddle **18** and saddle plates **38** with pins **28**. It should be noted that teeth **36** are formed at the upper ends of the upper links **16** and engaged with each other when assembled.

In the instant embodiment the hydraulic jack **12** may be a conventional portable jack so that it will be briefly described in this specification. That is, the hydraulic jack **12** generally comprises a main body **40** which in turn comprises a tank and a cylinder tube, a ram **42** slidably fitted into the cylinder tube, a pump **44** for pumping the working oil from the tank in the main body **40** into the cylinder tube for thereby lifting the ram **42**, and a pressure-relief valve **46** for returning the working oil from the cylinder tube to the tank for thereby lowering the ram **42**. All of the above described component parts of the hydraulic jack **12** are mounted on the seat **20**. The pump **44** generally comprises a pump cylinder **48** fixed to the seat **20**, a plunger **50** slidably fitted into the cylinder **48**, and a coupling member **54** for receiving an operating lever **52**. The coupling member **54** is pivoted with a pin **62** to the plunger **50** and also connected at one end thereof to the seat **20** through a connecting plate **56** with pins **58** and **60**.

A connecting member **64** securely fixed to the upper end of the ram **42** of the hydraulic jack **12** has a pair of extensions **66** whose width is smaller than the spacing between the pair of steel members forming each lower link **14**. A pair of auxiliary links **68**, which are the most important components of the present invention, are in the form of a yoke and have their one ends hinged with pins **30** to the extensions **66** of the connecting member **64** respectively, and their other ends hinged with pins **32** to the lower links **14**.

Next the mode of operation will be described. First the operating lever **52** is fitted into the coupling member **54** of the pump **44** and swung to reciprocate the plunger **50** in the pump cylinder **48**. Therefore the working oil in the tank of the main body **40** is drawn and forced into the bottom of the cylinder tube, thereby forcing the ram **42** to move up. The connecting member **64** fixed to the ram **42** is raised so that the lower links **14** are also lifted by the auxiliary links **68**. As a result both the upper and lower links **16** and **14** are extended. When the operating lever **52** is fitted onto and turns the pressure relief valve **46**, the latter is opened so that the working oil in the cylinder tube is returned to the tank. As a result the lower and upper links **14** and **16** are contracted or lowered under the force of the load exerted upon the saddle **18**. In the extension and contraction of the pantograph jack the movement of the lower links **14** is controlled by the

connecting member **64** through the auxiliary links **68**, whereas the movement of the pair of upper links **16** is controlled by the teeth **36** which engage with each other at the upper ends of the upper links **16**. Therefore the pantograph consisting of the hydraulic jack **12**, the lower and upper links **14** and **16** and the saddle **18** may always maintain its correct form so that the saddle **18** may be always maintained in the horizontal position.

Instead of the hydraulic jack a working oil source such as a hand or power pump may be disposed independently of the pantograph jack and hydraulically coupled through a tube or the like to a hydraulic cylinder interposed between the seat **20** and the connecting member **64**, so that the pantograph jack may be remote-controlled. In some cases, the lower and upper links **14** and **16** cannot be completely contracted by their own weight. In order to overcome this problem, return springs **74** may be connected, as shown in FIG. **2**, between a base **70** upon which is mounted the hydraulic jack **12** and a pair of arms **72** extended from the connecting member **64**.

From the foregoing description the construction and mode of operation of the pantograph jack **10** embodying the present invention are apparent to those skilled in the art. Next the relation between the lift x of the hydraulic jack **12** and the lift y of the pantograph jack **10** and the relation between the load W2 applied to the saddle **18** and the force exerted to the connecting member **64** will be described in detail.

Referring to FIG. **3** illustrating diagrammatically the principle of the pantograph jack **10**, for the sake of convenience of explanation the pins **24** coupling the lower links **14** to the seat **20** of the hydraulic jack **12** will be referred to as *a;* the pins **26** coupling the lower and upper links **14** and **16** together, *b;* the pins **28** coupling the upper links **16** to the saddle **18**, *c;* the pins **30** coupling the auxiliary links **68** to the connecting member **64**, *d;* and the pins **32** coupling the lower links **14** to the auxiliary links **68**, *e*. It is assumed that the distance between a and a be l_1; the distance between c and c, l_2; the distance between d and d, l_3; the distance between a and b, l_4; the distance between b and c, l_5; the distance between a and e, l_6; and the distance between d and e, l_7. Furthermore it is assumed that

$l_1 = l_2 = l_3$, and

$l_4 = l_5$.

Next referring to FIG. **4**, from the relation $l_7^2 = l_6^2 + x^2 - 2 \cdot l_6 \cdot x \cdot \cos\theta_1$

cos θ_1 of the triangle a, d, e is given by

$$\cos\theta_1 = (l_6^2 + x^2 - l_7^2)/2 \cdot l_6 \cdot x$$

Since $ab = bc = l_4$, the triangle a, b, c is an isosceles triangle.

Hence, $\theta_2 = \theta_1$.

Therefore the lift of the pantograph jack **10** is given by

$$y = 2 \cdot l_4 \cdot \cos\theta_1$$
$$= l_4/l_6 \cdot (l_6^2 + x^2 - l_7^2)/x$$
$$= l_4/l_6 \cdot x[1 - (l_7^2 - l_6^2/x^2)]$$

The ratio of the stroke of the hydraulic jack **12** to the lift of the pantograph jack **10** is given by

$$Y/x = l_4/l_6 \cdot [1 - (l_7^2 - l_6^2/x^2)]$$

The ratio of the load exerted on the pantograph jack **10** to the load exerted on the hydraulic jack **12** is given by the law of conservation of energy ($W_1 dx = W_2 dy$) by

$$W_1/W_2 = dy/dx = l_4/l_6 \cdot d/dx(l_6^2 + x^2 - l_7^2/x)$$
$$= l_4/l_6 \cdot d/dx[l_6^2/x + x - (l_7^2/x)]$$
$$= l_4/l_6 \cdot [1 + (l_7^2 - l_6^2/x^2)]$$

If the distance l_6 equals the distance l_7

$$y/x = l_4/l_6$$

and

$$W_1/W_2 = l_4/l_6$$

It is seen that the stroke ratio y/x and the load ratio W_1/W_2 are always equal, independently of the stroke x of the hydraulic jack **12**. This means that when the hydraulic jack **12** is extended or contracted at a constant speed, the pantograph jack **10** is lifted or lowered at a constant speed equal to l_4/l_6 of the speed of the hydraulic jack **12** and that when the load exerted to the pantograph jack **10** remains unchanged, the load W_1 exerted to the hydraulic jack also remains unchanged over the full stroke thereof.

However, when $l_6 > l_7$

$$y/x = l_4/l_6[1 + (l_6^2 - l_7^2/x^2)] > l_4/l_6$$
$$W_1/W_2 = l_4/l_6[1 - (l_6^2 - l_7^2/x^2)] < l_4/l_6$$

It is seen that the stroke ratio y/x is decreased as the stroke x of the hydraulic jack **12** increases and so is the load ratio W_1/W_2. This means that the force of the hydraulic jack **12** is minimum when the pantograph jack **10** starts to lift from the most contracted position and is gradually increased as the lift of the pantograph jack **10** is increased. Furthermore, the lift speed of the pantograph jack **10** with respect to that of the hydraulic jack **12** increases as the lift of the pantograph jack **10** is increased.

When $l_6 < l_7$

$$y/x = l_4/l_6 \cdot [1 - (l_7^2 - l_6^2/x^2)] < l_4/l_6$$
$$W_1/W_2 = l_4/l_6[1 + (l_7^2 - l_6^2/x^2)] > l_4/l_6$$

Therefore, as the stroke x of the hydraulic jack **12** increases, the stroke ratio y/x increases whereas the load ratio W_1/W_2 decreases. This means that as the pantograph jack **10** is raised the lift speed of the pantograph jack **10** with respect to that of the hydraulic jack **12** decreases, but the lift force becomes maximum when the pantograph jack **10** is about to be fully extended or lifted.

From the foregoing description a pantograph jack best adapted for the purpose of use may be freely designed by selecting a suitable length for the auxiliary link **68** and a position at which the auxiliary link **68** is connected to the lower link **14**. So far it has been assumed that $l_1 = l_2 = l_3$ and $l_4 = l_5$, but it will be understood that the above relations may be changed depending upon the purpose of the pantograph jack. Therefore the principle of the present invention may be also applied to a linkage **10***a* of the type shown in FIG. **5**, a parallel linkage **10***b* of the type shown in FIG. **6** and a cross linkage **10***c* of the type shown in FIG. **7**. The linkage **10***a* shown in FIG. **5** consists of two pantograph linkages, and the linkage **10***b* shown in FIG. **6** is also a pantograph because the lower and right links may be considered as lower links **14** shown in FIG. **1**, whereas the upper and left links may be considered as upper links **16**. The cross linkage **10***c* shown in FIG. **7** may be also considered as a pantograph because two links indicated by the chain lines of a pantograph may be considered to be extended toward the base **20**.

The present invention has been described in detail with particular reference to the preferred embodiments thereof but it will be understood that variations and modifications can be effected within the spirit and scope of the present invention as described hereinabove and as defined in the appended claims.

What is claimed is:

1. An extendible mechanism, comprising

a pantograph linkage including a pair of first links having first and second ends, a pair of second links also having first and second ends, first pivot means pivotably connecting said first ends of said first links, second pivot means pivotably connecting said second ends of said second links, and third pivot means pivotably connecting said second ends of said first links with said first ends of said second links;

a pair of auxiliary links having first ends which are pivoted to one another, and also having second ends;

fourth pivot means pivotably connecting each of said second ends of said auxiliary links with one of said second links intermediate said first and second pivot means in the region of the latter; and

an extendible device connected with said first ends of said auxiliary links and operative for displacing the latter in direction towards said first pivot means.

2. An extendible mechanism as defined in claim 1, wherein said extendible device comprises a hydraulic jack.

3. An extendible mechanism as defined in claim 2,

wherein said hydraulic jack comprises a base, and wherein said second pivot means comprises two second pivots each of which pivotably connects one of said second ends of said second links with said base of said hydraulic jack; further comprising a load-engaging saddle; and wherein said first pivot means comprises two first pivots each of which pivotably connects one of said first ends of said first links with said saddle.

4. An extendible mechanism as defined in claim 3, wherein said hydraulic jack further comprises a ram having a free end portion, and a connecting member fixed to said free end portion; and further comprising a pair of auxiliary pivots each pivotably connecting one of said first ends of said auxiliary links with said connecting member.

5. An extendible mechanism as defined in claim 3, wherein said first ends of said first links are formed with teeth which inter-engage with one another.

6. An extendible mechanism as defined in claim 3; and further comprising return spring means connected between said connecting member and said base and permanently urging the former to move towards the latter.

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