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Smith

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[45] **Jan. 1, 1974**

[54] **KINEMATIC EXTENSIBLE TRUSS MECHANISM**

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[52] **U.S. Cl.** **248/370,** 14/5, 248/284, 248/419, 248/424

[51] **Int. Cl.** **F16m 13/00,** E01d 15/00

[58] **Field of Search** 248/270, 280, 281, 248/284, 298, 324, 325, 370, 424, 419; 108/138, 149; 14/3, 5, 13, 14; 49/405

[56] **References Cited**

UNITED STATES PATENTS

2,066,425	1/1937	Sidwell	49/405 X
908,689	1/1909	McVey	248/370 X
1,174,881	3/1916	Ludlum	248/280
1,529,467	3/1925	Davis et al.	248/370
1,711,768	5/1929	Bausch et al.	248/281 X
2,256,004	9/1941	Thomas	249/424 X
2,837,307	6/1958	Schuager et al.	248/298 X

Primary Examiner—Allan D. Herrmann
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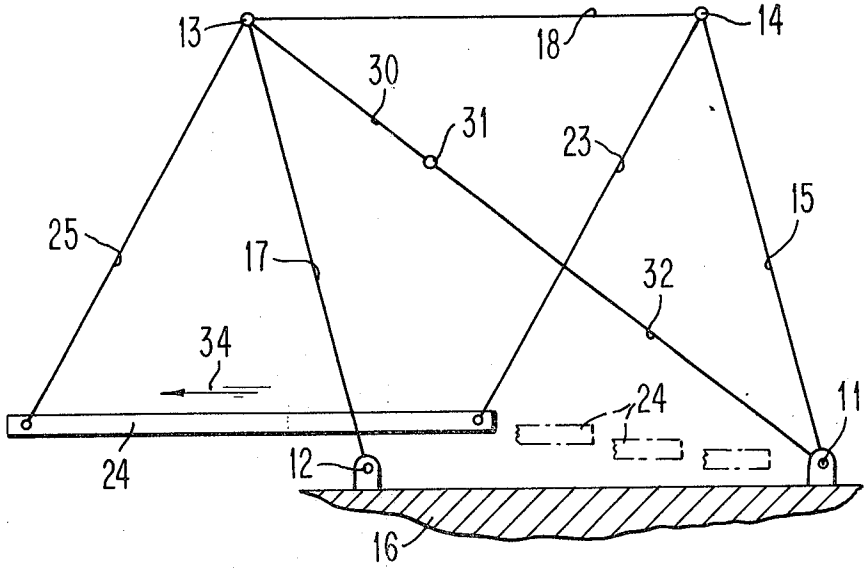
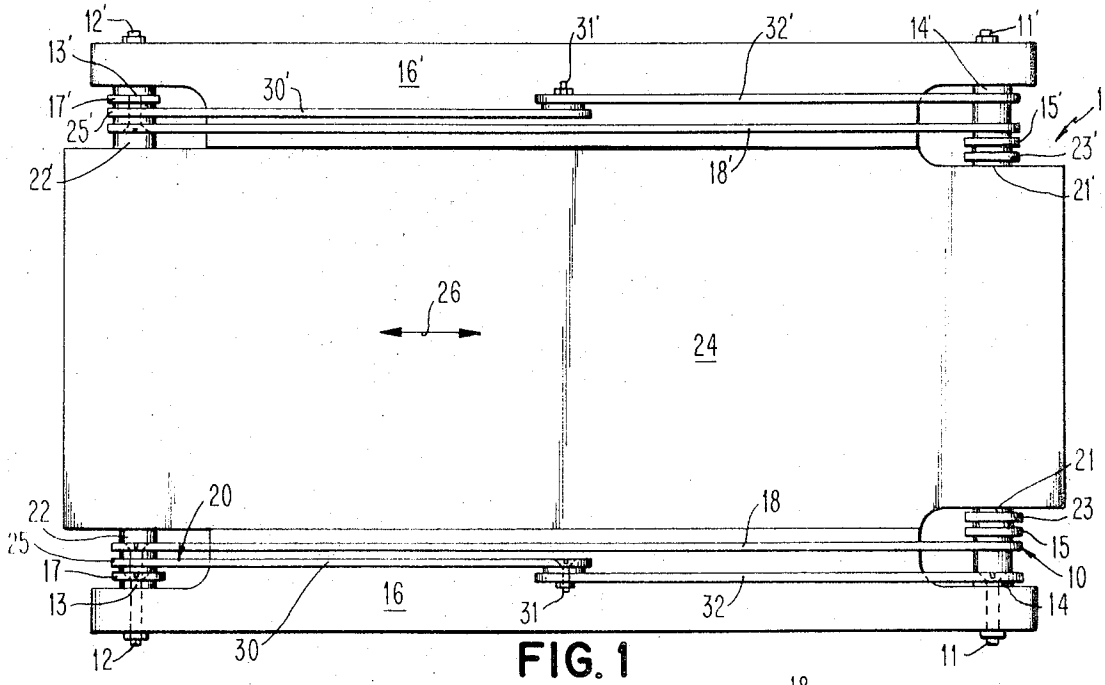
[57] **ABSTRACT**

A kinematic extensible truss mechanism comprising a first set of truss members arranged in a parallelogram with pivots at each of the junctures of the truss members, and a second set of truss members arranged in a parallelogram with pivots at each of the junctures of the second set of truss members. Two of the pivots of the first set coincide with two of the pivots of the second set, and at least one rigid extension projects from one of the truss members of the second set substantially at right angles thereton. An arm is pivotally connected to the rigid extension and connected for rotation to a pivot of the first set of truss members which is not common to the first and second set of truss members. In this manner movement of one of the truss members of one of the sets relative to another member of the other of the sets maintains parallelism of the one truss member to the other when relative motion occurs in a first direction, and results in an elevation of the one relative to the other when relative motion occurs in the opposite direction.

11 Claims, 8 Drawing Figures




12'
13'
17'
25'
22'
16'
30'
31'
32'
14'
11'
15'
1
23'
21'
18'
26
24
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18
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14
30
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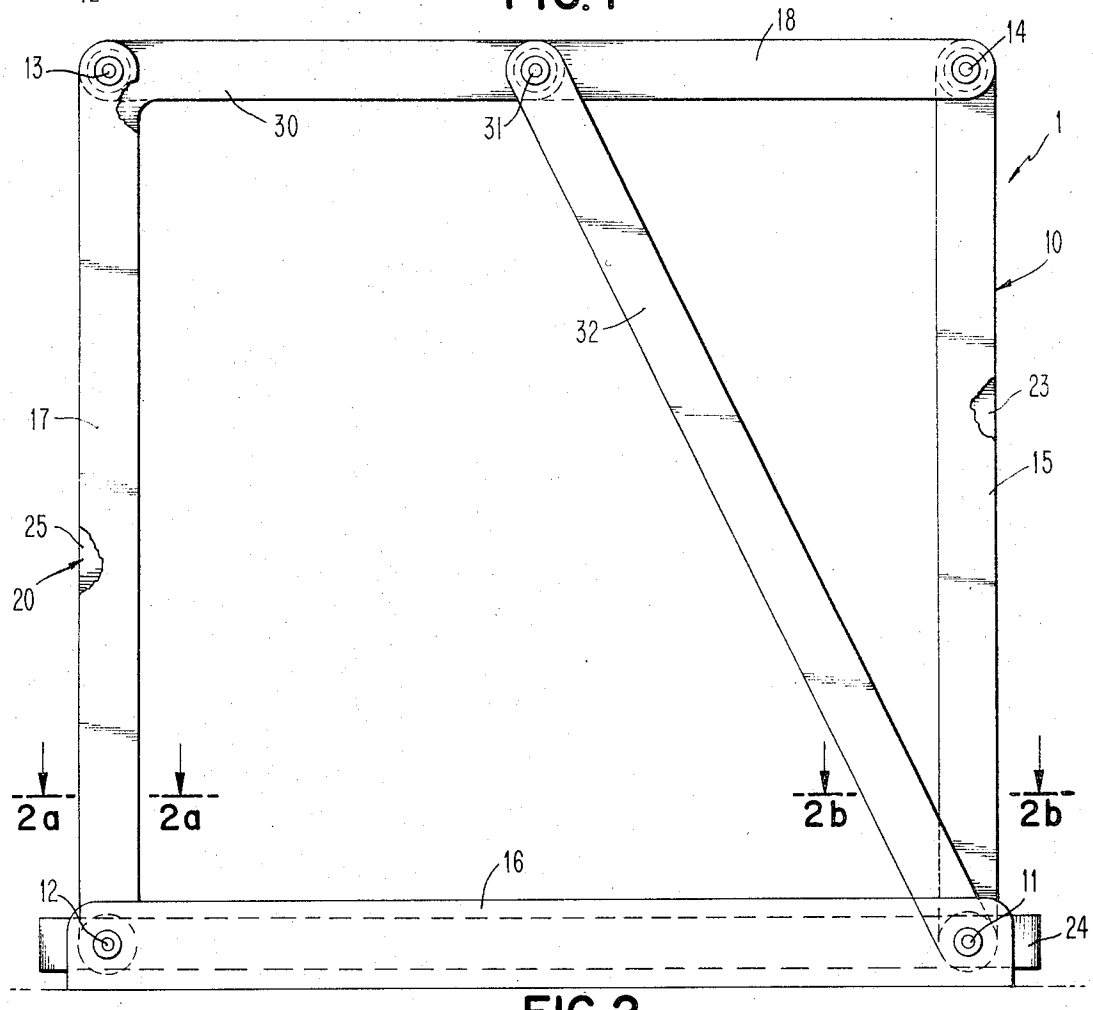
32
12
11

FIG. 1


18
14
13
30
31
1
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17
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25
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2a
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2b
16
12
11
24

FIG. 2

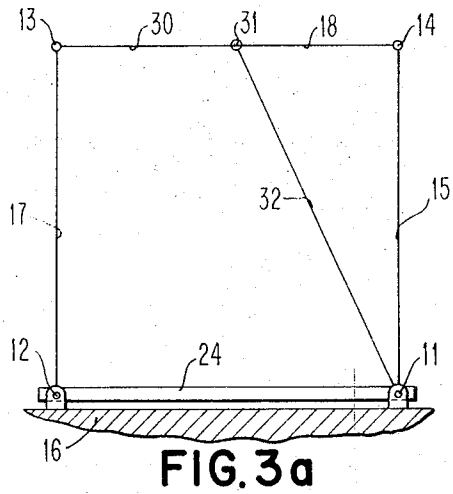

FIG. 3a

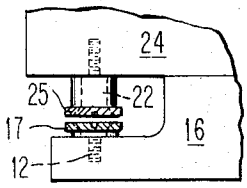

FIG. 2a

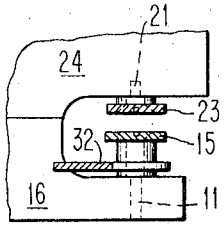

FIG. 2b

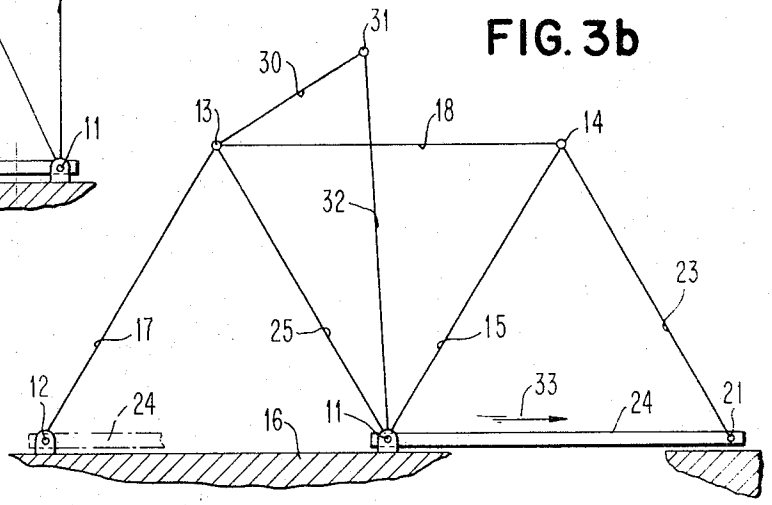

FIG. 3b

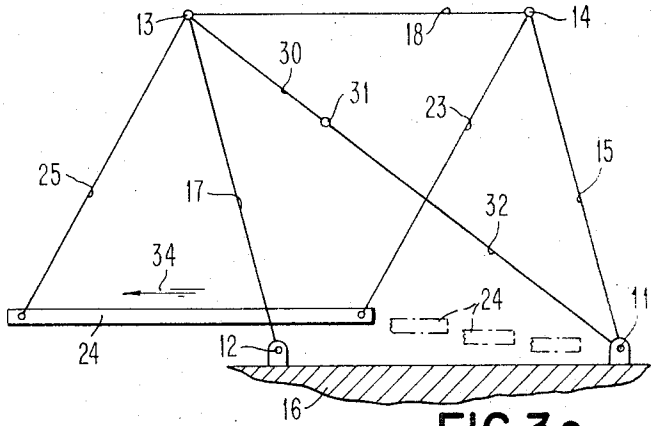

FIG. 3c

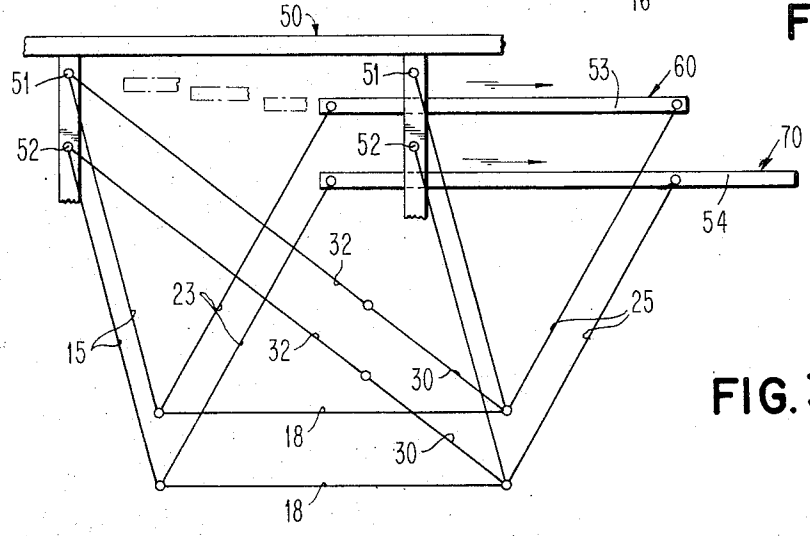

FIG. 3d

KINEMATIC EXTENSIBLE TRUSS MECHANISM

The purpose of this abstract is to enable the public and the Patent Office to determine rapidly the subject matter of the technical disclosure of the application. This abstract is neither intended to define the invention of the application nor is it intended to be limiting as to the scope thereof.

SUMMARY OF THE INVENTION AND STATE OF THE PRIOR ART

The present invention relates to truss mechanisms and more particularly relates to a kinematic extensible truss mechanism in which the moving support maintains parallelism relative to the fixed support when the first support is extended.

Relay racks utilized in machine controls as by a computer, or relays that are energized by and for the computer, are typically kept in drawers which may be extended from their home or nested position outwardly so that the various parts therein may be more readily serviced. Conventionally these relay racks or drawers are extremely heavy and tend to drop at their outer end when extended full length. This means that in order to reposition the drawer or rack in its home or nested position, after repair or servicing has been carried out, that the technician or engineer accomplishing such servicing must lift the end of the rack or drawer prior to reinserting the same into its home position. If the rack is heavy (and in most instances it is) the lifting of the end of the rack and sliding the same into its nested position can only be accomplished with difficulty.

The design of the extensible truss mechanism of the present invention, it has been discovered, may have many uses. For example, with the proper structural material, the mechanism may be useful as a portable bridge, easily put together in the field, and easily movable between an extended and retracted position. Additionally, it has been discovered that extension of the first support of the extensible truss mechanism in one direction relative to the second support thereof (which may be fixed), not only maintains its parallelism with respect to the second support but also maintains its position with regard to height above the second support, when extended in the one direction.

It was also discovered that while extending the first support in a first direction the parallelism and height above any fixed norm is maintained, an extension of the support in the opposite direction effects an elevation of the first support while maintaining parallelism. Thus the truss mechanism may be useful for applications such as loading or unloading docks or other elevated platforms by merely loading the first support in its extended and elevated position and then permitting the support to move downwardly, while maintaining parallelism with the second support, until the support is at its lowest level. Of course, inversion of the structure also results in a structure for elevating or raising the first support from a low position to a raised position.

Additionally, after the structure was developed, it was recognized that inverting the structure and providing a plurality of the same nested together permits the formation of nestable steps merely by extending the first support relative to the second support into the second direction.

In view of the above it is a principal object of the present invention to provide a kinematic extensible truss mechanism which is self-supporting and which

maintains the parallelism of the first support of the structure relative to the second support of the structure when the first support is moved relative to the second support in either direction.

Another object of the present invention is to provide a kinematic extensible truss mechanism in which extension of the truss mechanism of the support of the truss mechanism in a first direction maintains the support parallel to a norm and at a constant elevation with respect thereto.

Yet another object of the present invention is to provide a kinematic extensible truss mechanism wherein the first support, when moved in a direction opposite to the first direction remains parallel to a fixed norm while increasing its elevation with respect thereto.

Still another object of the present invention is to provide a kinematic extensible truss mechanism which is sturdy and may be constructed in the field, and which is economical to fabricate.

Other objects and a more complete understanding of the invention may be had by referring to the following specification and claims taken in conjunction with the accompanying drawings in which:

FIG. **1** is a plan view of apparatus constructed in accordance with the present invention;

FIG. **2** is a side elevational view of the apparatus illustrated in FIG. **1**;

FIG. **2***a* is a fragmentary sectional view taken along line **2***a*—**2***a* of FIG. **2**;

FIG. **2***b* is a fragmentary sectional view taken along line **2***b*—**2***b* of FIG. **2**; and

FIG. **3***a* – **3***d* are stick figures illustrating the position of the truss mechanism illustrated in FIGS. **1** and **2** when the first support is positioned in its nested condition (FIG. **3***a*); in its extended position in one direction (FIG. **3***b*); in its extended position in the opposite direction (FIG. **3***c*); and when in a nested position with a plurality of like truss mechanism and extended, as in FIG. **3***c*, to make steps.

Referring now to the drawings, and especially FIGS. **1** and **2** thereof, a kinematic extensible truss mechanism **1** constructed in accordance with the present invention is illustrated therein. To this end a first set of truss members **10** is arranged in a parallelogram with pivots **11, 12, 13,** and **14** at each of the junctures of the truss members **15, 16, 17,** and **18.** A second set of truss members **20,** in the present instance equal in length to the set of truss members **10,** is also arranged in a parallelogram with pivots **21, 22,** and common pivots **13** and **14** at the junctures of truss members **23, 24** and **25.** As shown truss member **18,** in the present instance, is common to both sets of truss members.

Inasmuch as the pivot **13** is common to the truss members **17** and **25,** while the member **17** is pivoted at its lower or remote end to the truss member **16,** and member **25** is pivoted at its remote end by a pivot **22** to its parallel truss member **24;** and truss members **15** and **23** have a common pivot at **14,** with their remote or lower ends pivoted respectively to the members **16** and **24** by pivots **11** and **21,** it is easy to see that relative motion may occur between the truss member **16** and truss member **24.** Thus in effect the truss member **16** acts as an outboard support which may be placed on the ground, or other stationary object while truss member **24** operates as a support or platform and may be moved relative to the member or support **16.** Of

course, support **24** could also be fixed and support **16** permitted to be moved.

In order to lend support to the structure of mechanism **1**, an identical pair of sets of truss members is provided on the opposite edge of the platform **24** with identical pivot points (aligned with the pivot points of the first and second set of truss members) which truss members and pivots have been designated with prime numbers corresponding to the base numbers heretofor given. As shown in FIG. **1** the pivots **21'** and **22'** join the second set of truss members to the support **24**, the truss members **23'** and **25'** being pivotally connected to the pivots **21'** and **22'** respectively.

In accordance with the invention, means are provided to maintain parallelism of the first support **16** with the second support **24** when the second support is moved relative to the first support, as indicated by the direction of the arrow **26** in FIG. **1**. To this end, a rigid extension **30** is connected to one of the upstanding truss members of the second set **20**, in the illustrated instance to the truss member **25**, and substantially at right angles thereto, the extension being also pivotally connected as by the pivot **13** such that as the member **25**, connected to the second support **24**, moves, the extension rotates about the pivot **13**. Additionally, pivotally connected to the extension **30** as by a pivot **31** is an arm **32** which is also mounted for rotation at its opposite longitudinal end by the pivot **11**. As before, a like extension **30'** is connected to the upstanding truss member **25'** as by the pivot **13'** and is pivotally connected as by a pivot **31'** to an arm **32'** which is connected to pivot **11'** of the first set of truss members on the opposite side of the support **26**. In this manner support and rigidity are added to the mechanism.

For the purposes of this application, it should be recognized that any permanent or fixed structure or other base member may replace the truss member **16**, as heretofor described in FIGS. **1** and **2**, so as to form the fourth side of the parallelogram, and thus "truss member" should be considered the ground or base upon which the pivots **11** and **12** are affixed. The operation of the mechanism of the present invention is best illustrated in the stick drawings of FIG. **3***a*–**3***c* wherein the support **16** or one side of the parallelogram of the first set of truss members is considered a base, norm or ground level. Referring now to FIGS. **3***a*–**3***c*, the mechanism is shown in FIG. **3***a* in its nested or home position, in side elevation. As the support **24** is moved in the direction of the arrow **33**, (FIG. **3***b*), members **15** and **17** of the first set of parallelograms, remain parallel to each other while the common truss member **18** remains parallel to the ground or base support **16**. As shown the rigid extension **30** moves counterclockwise with respect to pivot **13** while the arm **32** tends to move towards the vertical. Additionally, truss members **25** and **23** tend to remain parallel, and the action of the extension **30** and arm **32** compensates for the natural tendency of the support **24** to raise. Therefor, as shown in FIG. **3***b*, up to the point that pivot **22** aligns with pivot **11** (as shown in FIG. **3***b*) support **24** remains parallel to support **16** and there is no elevation of the support **24**. In a like manner, when the support **24** is moved in the direction of the arrow **34** (see FIG. **3***c*) truss members **15** and **17** tend to remain parallel and extension **30** rotates in a clockwise direction about pivot **13**, truss member **25** extending and effecting, in cooperation with truss member **23** of the second set, an elevation of the support **24**. Elevation of the support **24** will continue until the arm **32** is slightly over center with respect to the rigid extension **30** and pivot **31**.

Another way to look at the apparatus of the present invention is that it comprises a fixed support **16** and a moveable support **24**, and at least a first pair of upstanding truss members **17** and **25** which are joined adjacent one end of each by pivot means **13**. Pivot means **12** join the truss member **17** adjacent its opposite end to the fixed support **16**, while separate pivot means **22** join the other of the truss members **25** adjacent its opposite end to the moveable support **24**. A second pair of truss members **15** and **23** are axially spaced from the first pair of truss members and include pivot means **14** joining the truss members of the second pair of truss members. The opposite ends of each of the truss members **15** and **23** are respectively connected to the fixed and moveable support as by separate pivot means, i.e., truss member **15** is connected to pivot **11** and truss member **23** is connected to pivot **21**. A rigid extension **30**, extends perpendicularly from one of the truss members, in the present instance the truss member **25**, and an arm **32** extends from the extension **30** to the other of the supports (pivot **11**) and is pivotally connected adjacent its opposite ends to both the extension and the other support.

Thus the mechanism of the present invention permits the maintenance of coparallelism with regard to the support **16** and **24** when relative motion occurs between the truss members. Additionally, when the support **24** is moved relative to the support **16** in one direction, there is no elevation of the support **24** relative to the support **16** while movement in the opposite direction permits elevation of the support **24** relative to the support **16**.

It should be recognized that with the rigid extension **30** and arm **32**, the truss member **18** may be disregarded especially if the mechanism is to be used for light duty purposes. However, the structural integrity of the mechanism is enhanced with regard to longitudinal instability by employing the common brace truss member **18**.

In order to maintain parallelism of the support **24** relative to the support **16**, at least intermediate the pivots, it is desirable that the rigid extension **30** of the truss member **25** of the second set of truss members **20** be approximately 50 percent (in length) of the distance between the pivots **13** and **14**. Although other ratios will work, maximum extension while maintaining parallelism is effected.

It should be recognized that the structure has many uses. For example, the support **24** may be a drawer or the like which may be moved outwardly without drooping of the forward end, (extended end) such as illustrated in FIG. **3***b*. A structural analysis of the apparatus shows that increased pressure on the extended support or platform tends to cause an inward movement of the common truss members **18** and **18'**, i.e., towards each other. If loading, therefore, is severe, a brace or braces may be employed intermediate the common truss members to maintain their separation.

Additionally, inasmuch as the support **24** tends to elevate when extended in the opposite direction, the structure may be useful for loading or unloading docks, ships, loading ramps, etc., or in other circumstances where it would be advisable to have a structure which

would permit the loading and unloading from one level to another.

It should also be recognized that the structure lends itself, with a small ramp at either end of the movable support **24,** to being used as a portable bridge which may be easily constructed in the field. Additionally, as illustrated in FIG. **3***d*, an inversion of the structure with a plurality of mechanisms **50, 60,** etc. may be provided in a nested position, each of the base pivots being connected in a vertical plane as at **51, 52,** etc., to separate movable platforms **53** and **54** so that each will extend from the base or home or nested position with their supports lower than the next superimposed adjacent support, thereby forming steps.

Although the invention has been described with a certain degree of particularity, it is understood that the present disclosure has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts and the mode of operation may be made without departing from the spirit and the scope of the invention as hereinafter claimed.

What is claimed is:

1. A kinematic extensible truss mechanism, comprising in combination: a fixed support and a movable support; at least a first pair of upstanding truss members joined adjacent one end of each by pivot means; pivot means joining one of said truss members adjacent its opposite end to said fixed support, and separate pivot means joining the other of said truss members adjacent its opposite end to said movable support; a second pair of truss members axially spaced from said first pair of truss members and including pivot means joining said one truss member to said second truss member, the opposite ends of said truss members being respectively connected to said fixed and movable support by separate pivot means; a rigid extension projecting perpendicularly from one of said truss members connected to one of said supports, and an arm extending from said extension to the other of said supports and pivotally connected adjacent its opposite ends to both said extension and said other support.

2. Apparatus in accordance with claim **1** including means to maintain axial stability of said pairs and their positions, one pair with respect to the other pair.

3. Apparatus in accordance with claim **2** including a truss member connected intermediate said pivots joining each pair of truss members, one to the other.

4. Apparatus in accordance with claim **1** wherein the length of said rigid extension is approximately one-half the distance between the pivots joining the first and second pair of truss members.

5. A kinematic extensible truss mechanism comprising a pair of sets of truss members each set of truss members arranged in a parallelogram and pivot means pivotally connecting adjacent truss members of a set, each set of parallelograms having truss members equal in length to like truss members of the other set; a truss member common to each of said sets and pivotally connected adjacent its ends to truss members of each set; an extension of one truss member of said second set of truss members projecting at substantially right angles with respect thereto, and an arm pivotally connected to said extension and the diagonally opposite pivot means of said first set of truss members with respect to the pivot means of said one truss member.

6. Apparatus in accordance with claim **4** wherein said rigid extension has a length between pivots approximately one-half the distance between the pivots of said common truss member.

7. A kinematic extensible truss mechanism, comprising in combination: a first set of truss members arranged in a parallelogram, and pivot means at each of the junctures of said truss members; a second set of truss members arranged in a parallelogram, and pivot means at each of the junctures of said truss members; at least two of said pivot means of said first set corresponding to two of said pivot means of said second set; at least one rigid extension from one of said truss members of said second set and an arm pivotally connected to said rigid extension and connected for rotation to a pivot of said first set of truss members which is not common to said first and second set of truss members, whereby movement of said truss members of one of said sets relative to another member of the other of said sets maintains parallelism of said one truss member to the other when relative motion occurs therebetween.

8. Apparatus in accordance with claim **7** wherein when one of said truss members of said second set moves in one direction the height of said one truss member remains constant with respect to the parallel truss member of said first set.

9. Apparatus in accordance with claim **8** wherein when relative motion occurs in the opposite direction, said one truss member elevates with respect to the parallel truss member of said first set.

10. Apparatus in accordance with claim **7** wherein said rigid extension is disposed substantially at right angles to said one of said truss members of said second set.

11. Apparatus in accordance with claim **10** wherein said rigid extension has a length between pivots approximately one-half the distance between the pivot means common to both said first and second set.

* * * * *