No. 880,526. PATENTED MAR. 3, 1908.

H. S. HELE-SHAW.

VEHICLE.

APPLICATION FILED JUNE 27, 1907.

7 SHEETS—SHEET 1.

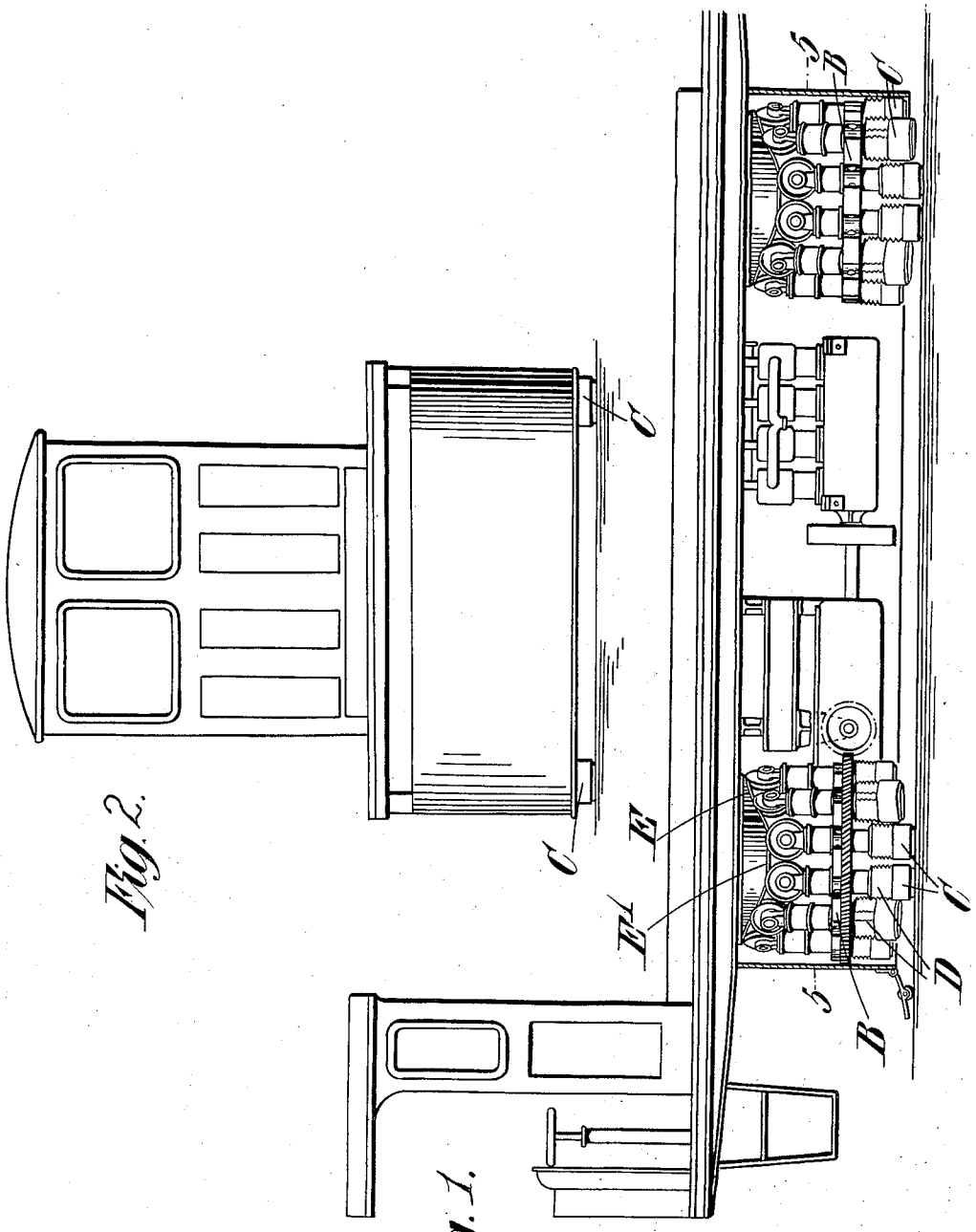


Fig. 2.

Fig. 1.

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7 SHEETS—SHEET 2.

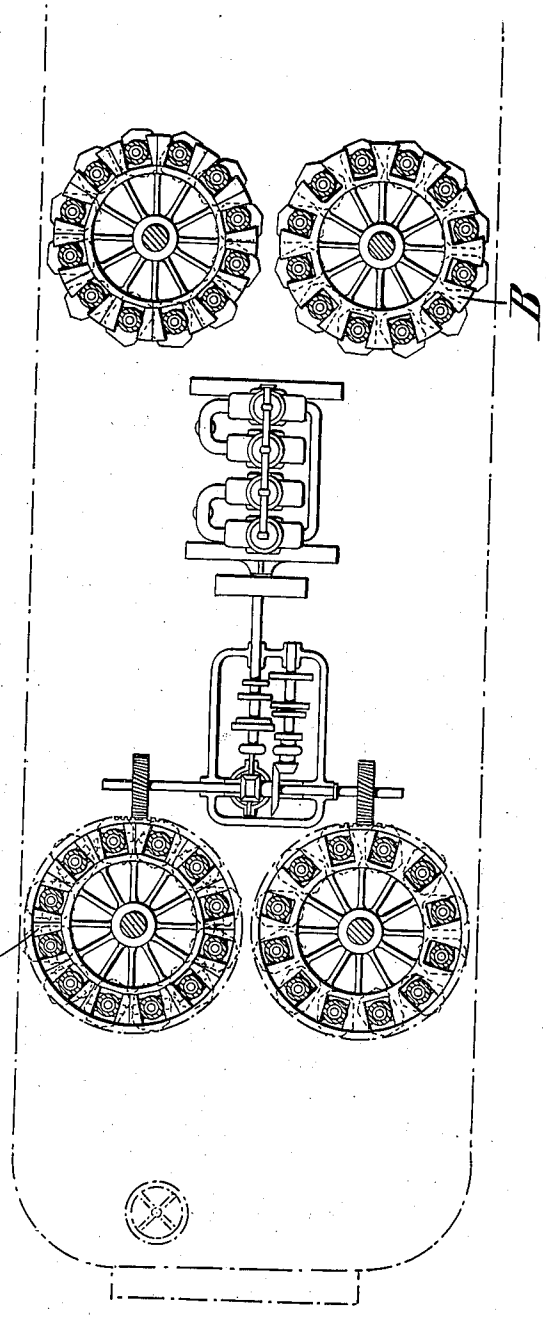


Fig. 3.

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7 SHEETS—SHEET 3.

Fig. 4.

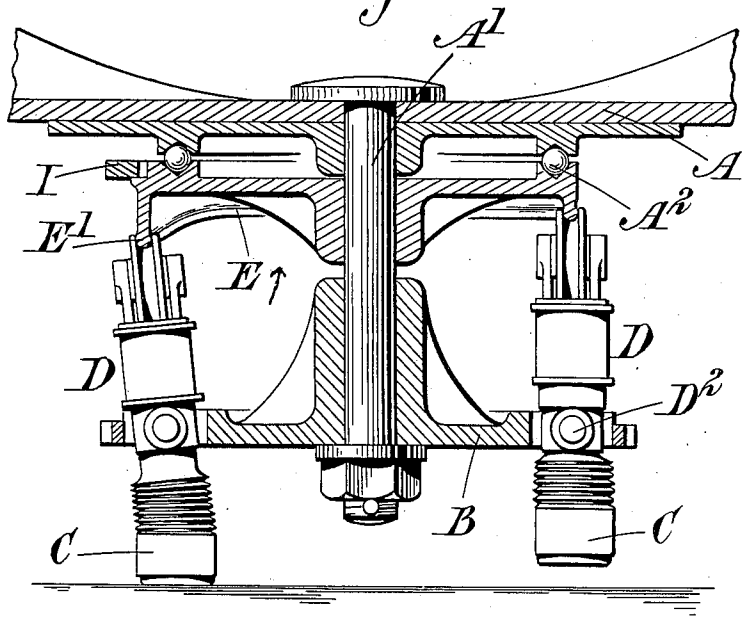
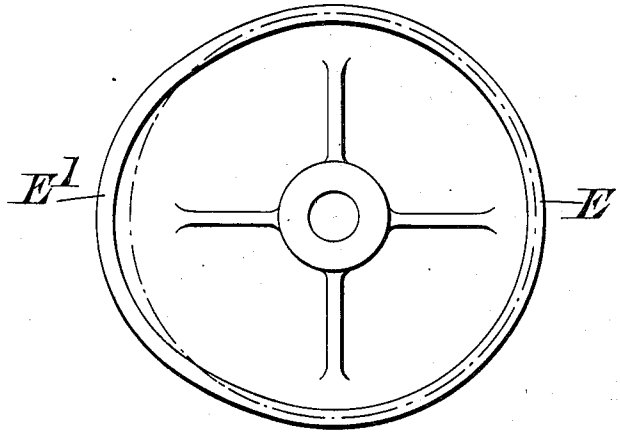


Fig. 5.



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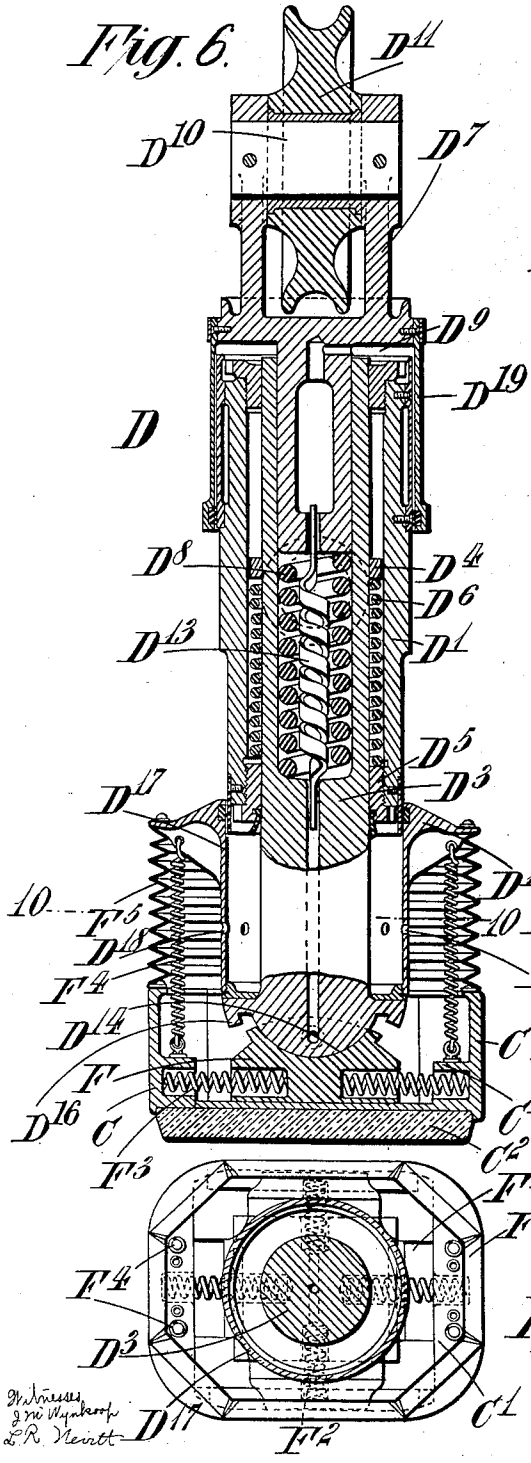
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7 SHEETS—SHEET 4.

Fig. 6.



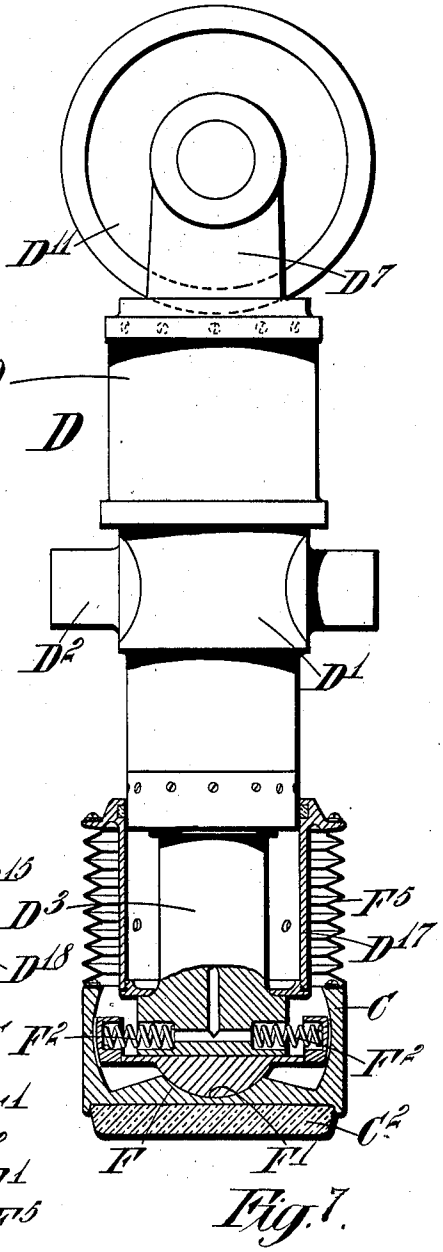


Fig. 7.

Fig. 8.

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7 SHEETS—SHEET 5.

Fig. 9.

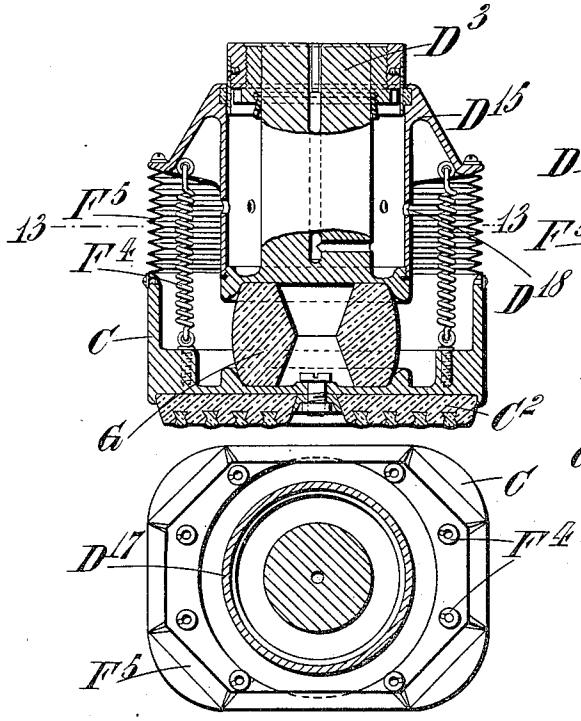


Fig. 10.

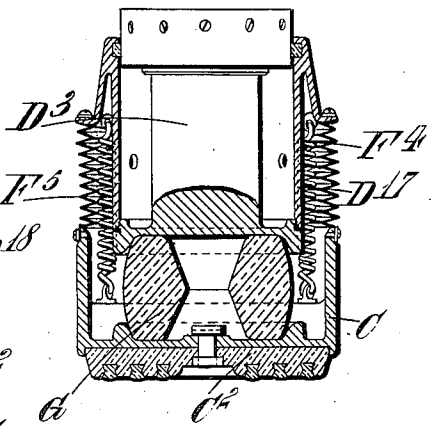


Fig. 11.

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Fig. 12.

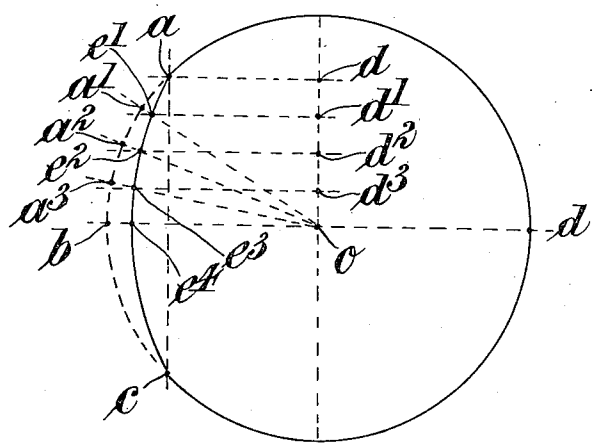
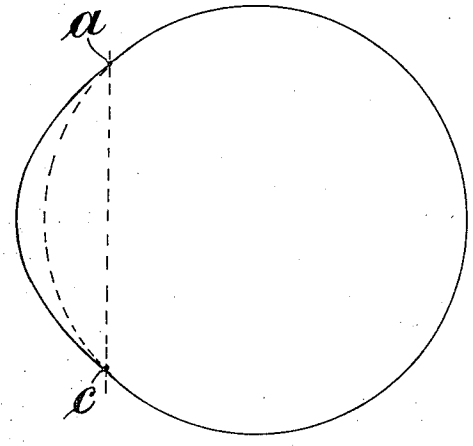


Fig. 13.



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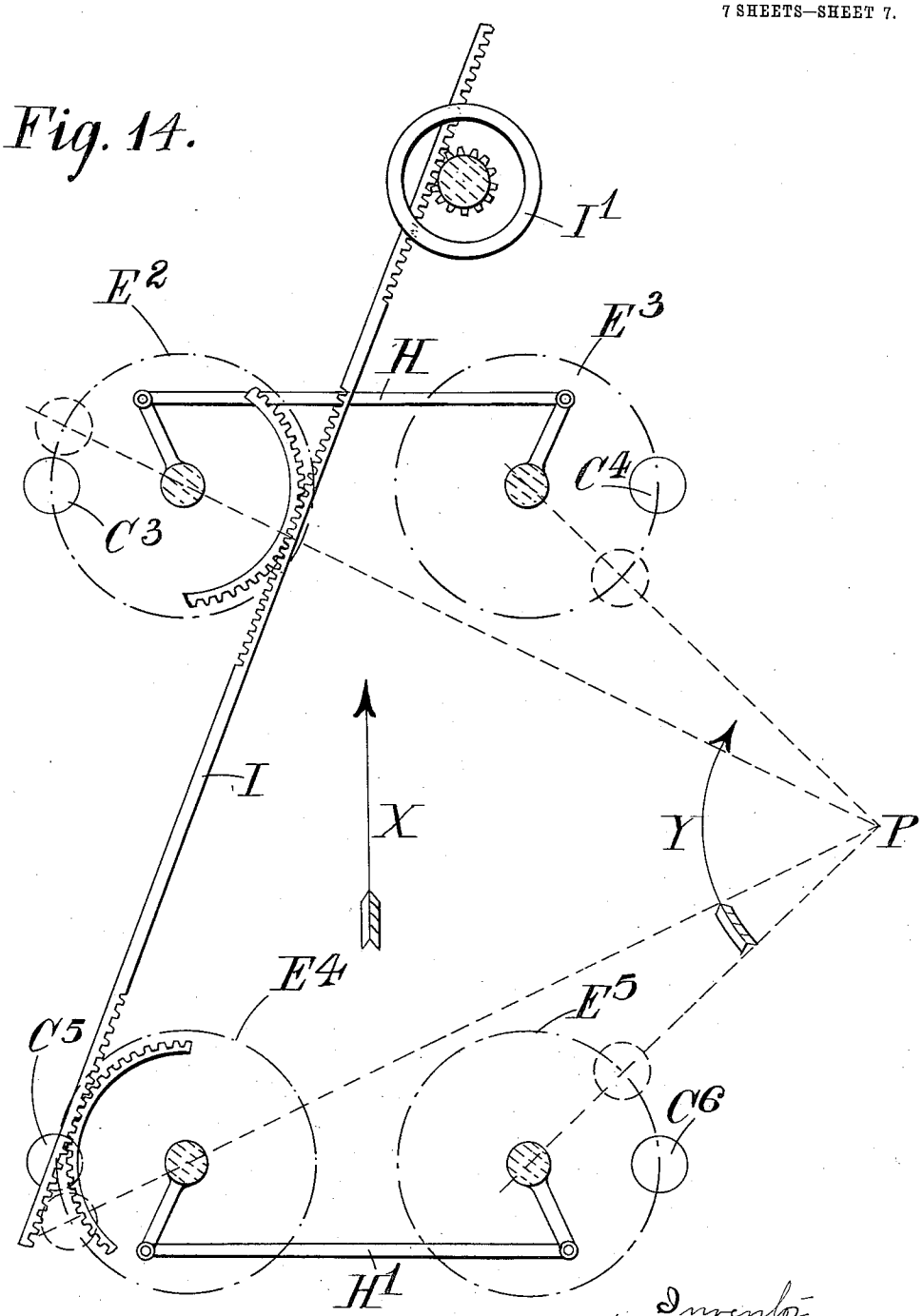
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VEHICLE.

APPLICATION FILED JUNE 27, 1907.

7 SHEETS—SHEET 7.

Fig. 14.



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UNITED STATES PATENT OFFICE.

HENRY SELBY HELE-SHAW, OF LONDON, ENGLAND.

VEHICLE.

No. 880,526. Specification of Letters Patent. Patented March 3, 1908.

Application filed June 27, 1907. Serial No. 381,161.

To all whom it may concern:

Be it known that I, HENRY SELBY HELE-SHAW, a subject of the King of England, residing in London, England, have invented certain new and useful Improvements in or Relating to Vehicles, of which the following is a specification.

My invention relates to improvements in methods of transporting bodies on land by the use of feet. These feet are arranged to alternately rest upon the ground allowing the body to move over them and to be picked up and carried to a new position so as to enable the body to be transported to be carried smoothly along.

The particular type of contrivance now described which transports bodies by a movement somewhat corresponding to the action of walking may for convenience be termed a walking transporter or more briefly a transporter.

In order to give an idea of the action and general appearance of a transporter constructed according to one embodiment of this invention it may be assumed that the frame of a vehicle is provided with four wheels or carriers placed in a horizontal position beneath the frame and arranged to rotate about vertical axes. These carriers support the body or frame-work of the transporter by means of a series of feet carried by legs the latter projecting down from the periphery or circumference of the wheels parallel to their axes of rotation. Let it be assumed that all four wheels have their four axes situated in plan at the four corners of a rectangle. Let this rectangle be smaller than an ordinary vehicle such as a wagon or lorry as seen in plan so that the four carriers are underneath and just concealed in plan by the frame of the vehicle in question. Then if the legs and feet which are adjacent to the longest side of the frame are those which are lowered the transporter will be resting on four or more supports in the form of feet. The position of these supports on the ground will correspond approximately to the position of the points of contact of the four wheels of an ordinary vehicle. Suppose now the four carriers are made to rotate by some source of power either carried on the transporter or external to it, then, if by suitable mechanical contrivances it is arranged that the connection between the feet and the transporter can slide or move otherwise to a small extent laterally and also that the feet can be picked up when they are no longer adjacent to the outer edge of the framework, other feet being brought down to take their place, it is evident that, since the feet are in turn for a short time at rest relatively to the ground, over which they are not themselves supposed to slide, the axes of rotation will be carried along in the direction of the longer or outer sides of the rectangle. Thus the transporter, relatively to which the axes always have the same fixed position, will be itself carried along.

One of the chief features of this invention consists in providing in combination with a vehicle or transporter a propelling or supporting device comprising a carrier rotating in a horizontal plane and having feet or equivalent which are successively depressed to engage the ground at the appropriate place and again raised to their normal height clear of the ground.

Another important feature of this invention is that the feet which are depressed on to the ground to support the body of the transporter may be changed without necessarily rotating the carrier.

A further feature of this invention is that by arranging that the position may be shifted at which the feet are depressed on to the ground relatively to the body of the vehicle the result is obtained that the vehicle can be moved in any direction or rotated about any point.

Other features of this invention will be evident from the following description taken in connection with the accompanying drawings in which:—

Figure 1 shows in elevation a lorry having transporting means constructed according to the same embodiment of this invention the casing surrounding the legs and feet being broken away. Fig. 2 is an end elevation of the same. Fig. 3 is a section on the line 5—5 of Fig. 1. Fig. 4 is a section on an enlarged scale of one of the carriers showing the method of supporting the feet and the cam rail. Fig. 5 is a view of the cam rail looking in the direction of the arrow in Fig. 4. Fig. 6 is a section of one form of leg and foot suitable for employment in this modification of the invention. Fig. 7 is a side elevation partly in section of the same the view being at right angles to that shown in Fig. 6. Fig. 8 is a section on the line 10—10 in Fig. 6.

Fig. 9 shows in section part of another construction of leg and foot. Fig. 10 is a section of the same taken at right angles to that shown in Fig. 9. Fig. 11 is a section on the line 13—13 of Fig. 9. Fig. 12 is a diagram showing the path which it is desirable the connection between the leg and foot should move over. Fig. 13 is a diagram showing the required shape of the cam rail to give the desired movement to the connection between the leg and foot. Fig. 14 is a diagram illustrating one method of arranging the steering mechanism.

Like letters indicate like parts throughout the drawings.

Referring to Figs. 1 to 8 a lorry having similar transporting means is shown. The frame A of the vehicle supports vertical spindles A^1 (Fig. 4) on which horizontal carriers B can rotate. Each carrier supports a number of feet C by legs D. The top of each leg is provided with a roller which bears against the rail E. This rail is in the form of a closed curve not necessarily or in general of circular form for reasons which will be more fully explained hereinafter. It is for the most part horizontal but at the part E^1 where the leg is to be depressed it projects downwards, forming a cam—for this reason the rail may be referred to as the cam-rail. When the carrier is rotated the legs and feet are therefore successively depressed on to the ground supporting the body of the vehicle. The cam-rail E is rotatable for reasons to be explained hereinafter and a ball-bearing A^2 separates it from the frame A. In the modification shown the two front carriers are driven from an engine through helical gearing, the two back carriers trailing.

Referring more particularly to Figs. 4, 6, 7, and 8, each leg D consists of two main portions which are movable relatively to each other. The outer portion D^1 is provided with trunnions D^2 which are supported in suitable bearings on the carrier B. The inner portion D^3 of the leg supports the foot C. A collar D^4 is provided on the member D^3 and between this collar and a flange D^5 on the outer member D^1 is a helical spring D^6. The inner member D^3 is therefore supported on the outer member by means of the spring D^6. The lower cylindrical portion of a frame D^7 is capable of sliding in the member D^3. Between the frame D^7 and member D^3 a spiral spring D^8 is provided which serves to prevent shock being transmitted from the foot to the vehicle. The frame D^7 has a hole D^9 allowing air to escape on the depression of the leg on to the ground. A spindle D^{10} is mounted on the frame D^7, this spindle supporting a roller D^{11} which engages with the cam rail E as previously described. The frame D^7 and inner member D^3 are connected by a spiral torsion spring D^{13} which permits the foot to rotate relatively to the outer member of the leg D^1 when necessary.

In order to allow the connection between the leg and foot to be flexible a modified form of a Hooke's or universal joint is employed. This joint is constructed in the following manner:—The lower end D^{14} of the inner member D^3 of the leg is of cylindrical form and fits into a corresponding recess in an intermediate member F. The lower surface F^1 of the intermediate member F is also of cylindrical form but the axis of this cylinder is at right angles to the axis of the surface D^{14}. Spiral springs F^2 are provided between the inner member D^3 and the intermediate member F, and springs F^3 between the intermediate member F and the foot C. The foot C and parts of the universal joint are held in position by spiral springs F^4 attached to a flange D^{15} on the sliding case D^{17} surrounding the outer member D^1. Stops D^{16}, C^1 are provided to prevent the twisting of the foot to too great an extent. The foot C may be provided as shown with any suitable form of tread such as C^2. Air holes D^{18} are formed in the casing D^{17} and at other suitable places to allow the free depression of the leg. The universal joint is surrounded by a protective casing F^5 of the concertina type and a protective casing D^{19} is attached to the frame D^7 and protects the connection between the frame D^7 and inner member D^3.

With a joint of the form described flexibility is allowed in two directions viz: (1) The canting of the foot relatively to the leg when the former rests on uneven ground, and (2) the lateral motion of the sole of the foot as a whole relatively to the leg while at the same time the turning of the sole of the foot about a vertical axis relatively to the inner portion of the leg is prevented and the casing F^5 protected from twisting and breakage.

The modification of the Hooke's joint differs from the usual form in two essential particulars, first, instead of preventing relative lateral movement of the gimbal or cross-block of the Hooke's joint and the parts which it connects together, provision is made so that sliding can take place in two directions at right angles. This enables the sliding to take place in properly prepared cylindrical surfaces so that by a combined movement in two perpendicular directions the resultant relative movement of the foot and the inner part of the leg can take place in any required direction. The other important modification is in the employment of only a portion of the complete circle of the ordinary pins of the Hooke's joint. This can be done owing to the fact that only a limited angular movement or canting of the foot is required in any direction and hence, while the strength of the joint is increased

for a given weight of metal, the connecting joint is lowered for the portions of pins can be set closer than complete cylindric pins, thereby increasing the stability of the structure. At the same time, the foot which is no longer attached to the leg by positive connection of a completely circular pin joint is, by means of the spring connection which according to the present invention, can now be adopted, of a nature to prevent backlash and yet sufficiently strong to raise the feet under all conditions required to be fulfilled. In the event of any unforeseen accident tending to detach the foot from the leg, the tensile resistance of the springs is overcome when a dangerous strain is reached and the foot is separated from the leg without causing damage to the machine as a whole. Owing to the provision of springs the foot on being raised from the ground assumes its normal position both laterally and horizontally relatively to the inner portion of the leg the same springs also preventing any movement taking place unless a suitable measure of force is applied to effect that movement, undue shock or vibration being at the same time obviated.

In Figs. 9, 10 and 11 a modified construction of leg and foot is shown. In this modification the universal joint is dispensed with and in its place an india rubber ring G is employed to give the required flexibility between the foot and leg. The india rubber ring may be reinforced and it may be vulcanized or otherwise attached both to the lower part of the leg and to the foot. The construction of this form of leg is otherwise substantially the same as described in the modification shown in Figs. 6, 7 and 8. When the wheel rotates with uniform motion, the motion of a point on the circumferences projected to any chord is no longer uniform but is harmonic. Hence when a foot is placed on the ground and remains there before being picked up the point of attachment between the transporter and the revolving carrier tends to move in a circle the actual path traced out however being in the direction of motion of the transporter or tangential to the circle referred to, the velocity along this path, if the transporter is moved forward uniformly varying harmonically. Consequently unless some provision is made there will be a continuous tendency to alter the distance between the point of attachment of the carrier to the transporter and the foot on the ground with either a resulting slipping of the foot on the ground or a resulting strain to the feet and carriers. By using a particular curve for the path of connection between the inner portion of the leg and foot it is possible to obviate this tendency, which, although modified by the springs in the foot above referred to, would undoubtedly tend to cause vibration and wear of the connecting joints. In order to follow the correct curve, the closed curve of the cam rail, if a cam rail be used, must be given a definite form and the attachment of the outer portion of the leg to the frame must be either a sliding joint or a pivoted bearing in order to enable the lower part of the inner portion of the leg to have the movement required.

Figs. 12 and 13 show diagrammatically the correct curve for the path of the connection between the inner portion of the leg and the foot and the necessary form of the cam rail respectively. The circle *a b c d* represents the path of the support of the leg. The curve taken by the connection between the inner portion of the leg and foot does not follow this circle completely but follows a path represented by the curve *a c* on the left-hand side of the chord *a c*. This curve may be derived by the following construction:— Through the point *a* a line *a d* is drawn parallel to *b o* the arc *a b* is divided into a number of equal parts and the line *d o* into a similar number of equal parts such for example as four, radii $o\ a^1$, $o\ a^2$, $o\ a^3$ are drawn and lines through $d^1\ d^2\ d^3$ parallel to *o b* the intersection of these latter parallel lines with the radii give points $e^1\ e^2\ e^3$ on the curve. The curve of the cam rail shown in Fig. 13 is partly circular but bulges outside the circle to an amount equal to that which the curve in Fig. 12 lies within the circle. Fig. 5 previously referred to also shows the bulging of the cam rail and the supporting of the legs on trunnions so that they can follow a cam rail curved as just explained.

A transporter constructed according to this invention may be arranged to be steered in an entirely different manner to that usually employed with a vehicle. In order to explain the method of steering, let it be assumed that the legs are being brought to the ground by means of a cam rail. As long as the position of the downwardly projecting parts of the cam rail of the two front horizontal carriers is such that they are adjacent to the respective outer sides of the transporter, that is to say, the middle of the projections of the cam rails lie on the straight line which passes through the axes of the two front revolving carriers being at the same time parallel to the front and back ends of the body of the vehicle assumed to be rectangular in plan, the transporter will, when the carriers turn uniformly at the same rate, move forward in a straight line. If however, the projecting portions of the cam rail are turned into certain suitable positions and the feet brought to the ground, not as formerly, adjacent to the outer edge of the transporter but into other positions, the transporter will no longer necessarily move forward in a straight line, but will tend to turn in a manner and to an extent which depends on the nature of the movement to

which the projecting portions of the cam rails have been subjected. A similar thing will result from the adjustment of the rear cam rails which with corresponding legs and feet are supporting the rear end of the vehicle. This method of varying the positions of the projecting portions of the cam rails affords a means of steering the transporter which does not to any appreciable extent interfere with the stability of the vehicle.

Although my present invention differs entirely from that by which the wheels of an ordinary motor vehicle are suspended, which latter involves certain serious defects, both mechanically and structurally, caused by the turning of the plane of the wheels, as well as by the overhung suspension, which defects are entirely avoided in the method of steering above described in connection with the transporter, there is one point of resemblance which, to avoid undue detail of description, may be mentioned. This point is in regard to the geometrical method by which the projecting cams may be turned to the right positions so that, when the vehicle is turning, there may be no undue tendency to drag the feet bodily over the ground. This enables the convenient application for the transporter of what is known as the Ackermann method of arranging the steering levers. The problem to be solved in the case of a motor vehicle is that the axes of rotation of all the wheels, when the vehicle is turning or changing its direction, shall pass in plan through the same point. In the present problem the condition to be effected is that the lines in plan which join the center of the projecting part of each cam rail with the axis of rotation of the horizontal wheels shall in plan also pass through the same point. This point, when the vehicle is moved straight forward, is as in the case of the ordinary motor vehicle, at an infinite distance, but under all other circumstances is a definite point, and therefore, although the two problems are mechanically very different, the geometrical solution is the same. The Ackermann system of connecting-lines although not exact may as one alternative be used in order to insure that the cams are approximately turned into their correct position. In the case of a motor vehicle, provision has to be made for the different speeds at which the inner and outer wheels have to move, when the vehicle is turning a corner. The same is the case with the inner and outer feet of the transporter and may be effected, as with motor vehicles, by the use of a differential gear or by means of some form of free wheel axle or by driving each wheel by a separate and independent motor. Similar means may be adopted in connection with the turning of the transporter and advantage may also be taken, as is sometimes the case with ordinary motor vehicles, of retarding the inner wheel or accelerating the outer wheel in order to assist the action of steering. In the case when the cam rail is not used, steering may be effected by employing any suitable means of bringing the feet to the ground in the correct positions required in steering, the geometrical conditions to be observed being that the positions are such as have been already stated.

In Fig. 14 an arrangement of Ackermann links H H^1 connecting the cam rails E^2 E^3 and E^4 E^5 respectively are shown. The cam rails E^2 and E^4 are provided with spur wheels and a rack I operated by the steering wheel I^1 which engages with them. With the cam rails in such a position that the feet C^3 C^4 C^5 C^6 are depressed at the positions shown indicated by full lines, the vehicle would move forward in the direction of the arrow X. If the steering wheel is turned so as to change the positions of the cam rails so that the feet now come into contact with the ground at positions indicated by the dotted lines the vehicle will rotate about the point P as indicated by the arrow this point P being the point of intersection of the lines joining the center of the cam rail to the center of the foot in contact with the ground.

In Fig. 4 the cam rail E is shown separated from the frame A by a ball bearing A^2 and a rack and pinion I^1 is provided for rotating the carrier as just described.

Various modifications may obviously be made in the methods of carrying my invention into effect. For example, instead of raising and lowering the feet by means of cam rail, a hydraulic method may be employed. According to this method the leg may be made in two portions, an outer and an inner, the outer one in the form of a cylinder and the inner of a piston, and fluid may be used to depress and raise the outer portion as required. A supporting cam rail may be used in this method. If a separate cam rail is not used the carrier itself will have to be constructed so as to withstand the stresses due to the load acting transversely to its plane.

Instead of supporting the legs on a carrier in the form of a wheel and forming them of an inner and outer part relatively movable they may consist each of only one part supported on a lever which is arranged to normally hold the feet out of contact with the ground but allows them to be depressed on the ground when required. Though it is preferable to shape the cam rail as described in connection with Figs. 12 and 13 in some cases a cam rail of circular or other shape may be employed.

Instead of employing flexible connections between the leg and foot such as described, a pneumatic connection may obviously be employed. Instead of employing the particular method of steering described a pair of

carriers might be attached to a frame corresponding to the bogie truck of a railway carriage of the fore-carriage of an ordinary vehicle; this frame being arranged to turn to steer the vehicle.

Arrangements may be made in addition to the spring arrangements already mentioned by which any form of carriage body on the transporter such as a motor omnibus may be suitably supported by springs. Springs of metal or indiarubber may be supplied at the point where one moving part comes into contact with another, such for instance, in the particular modification shown in the drawings, as where the roller at the head of the inner portion of the leg comes in contact with the projecting portion of the cam rail.

Any means of propelling the transporter may obviously be adopted. It may either be self-propelled or drawn by external means, such as the tractive efforts of animals. In the case when the transporter is self-propelled either one pair of adjacent revolving carriers *i. e.*, the front or back pair or all four carriers may be driven simultaneously by the motive power.

The carriers may obviously take various forms other than those previously referred to and in the following claims by the term "carrier" is intended to be included any rotatable supporting device which may be in the form of a wheel as shown in the drawings but which may of course take other forms. The carrier is described as being in a "horizontal plane" and speaking generally it would be so but I wish it to be understood that it might be placed at a greater or smaller angle with respect to the horizontal plane, the essential point being that according to this invention the carrier does not rotate in a vertical plane or anything approaching that and that the feet are projected from the side or face of the carrier and not from its periphery or in the plane of the carrier; in other words, the feet are projected in a direction substantially perpendicular to the plane of the carrier and not in the plane of the carrier.

What I claim as my invention and desire to secure by Letters Patent is—

1. The combination with a vehicle or transporter of a carrier rotatable in a "horizontal plane", feet supported by said carrier and movable relatively thereto, and means to successively depress said feet relatively to the carrier to engage the ground and to raise them clear of the ground.

2. The combination with a vehicle or transporter of a carrier rotatable in a "horizontal plane", feet supported by said carrier and movable relatively thereto and means to successively depress said feet relatively to the carrier to engage the ground and to raise them clear of the ground such movements resulting in or permitting a movement of the vehicle relatively to the ground.

3. The combination with a vehicle or transporter of a carrier rotatable in a "horizontal plane", feet supported by said carrier and movable relatively thereto, means to successively depress said feet relatively to the carrier to engage the ground and to raise them clear of the ground and means carried by the vehicle to rotate the carrier.

4. The combination with a vehicle or transporter of a carrier rotatable in a "horizontal plane", feet supported by said carrier and movable relatively thereto, means to successively depress said feet relatively to the carrier to engage the ground and to raise them clear of the ground and means for varying the position relatively to the vehicle at which the feet engage the ground.

5. The combination with a vehicle or transporter of a carrier rotatable in a "horizontal plane", feet supported by said carrier and movable relatively thereto, means to successively depress said feet relatively to the carrier to engage the ground and to raise them clear of the ground, and means for steering the vehicle comprising mechanism for varying the position relatively to the vehicle at which the feet engage the ground.

6. The combination with a vehicle or transporter of a carrier rotatable in a "horizontal plane", feet supported by said carrier and movable relatively thereto and a cam-rail engaging with the feet to depress them successively relatively to the carrier to engage the ground.

7. The combination with a vehicle or transporter of a carrier rotatable in a "horizontal plane", feet supported by said carrier and movable relatively thereto, a cam-rail engaging with the feet to depress them successively relatively to the carrier to engage the ground, and means for altering the position of the cam-rail relatively to the vehicle.

8. The combination with a vehicle or transporter of a plurality of carriers rotatable in a "horizontal plane", a set of feet supported by each of said carriers and movable relatively thereto, means to successively depress the feet relatively to the carrier to engage the ground and to raise them clear of the ground and steering mechanism for varying the position relatively to the vehicle at which the feet engage the ground, such mechanism being so arranged that the lines in plan which join the axes of rotation of the carriers with the centers of the feet engaging the ground pass through one point.

9. The combination with a vehicle or transporter of a plurality of carriers rotatable in a "horizontal plane", a set of feet supported by each of said carriers and movable relatively thereto, a cam-rail engaging with the feet to depress them relatively to the carrier, couplings joining the carriers in pairs and steering mechanism for altering the position of the cam-rails relatively to the vehicle, the

coupling and steering mechanism being so arranged that the lines in plan which join the axes of rotation of the carriers with the centers of the feet engaging the ground pass through one point.

10. In a vehicle or transporter the combination with a rotatable carrier of a leg comprising an outer frame or casing journaled in the carrier, an inner member, a resilient connection between the outer frame and the inner member, and a foot free to move within limits in two directions relatively to the leg.

11. In a vehicle or transporter the combination with a rotatable carrier of a leg comprising an outer frame or casing journaled in the carrier, an inner member, a resilient connection between the outer frame and the inner member, a foot free to move within limits in two directions relatively to the leg, and springs to return the foot when displaced from its normal position relatively to the leg.

12. In a vehicle or transporter the combination with a rotatable carrier of a leg comprising an outer frame or casing journaled in the carrier, an inner member, a resilient connection between the outer frame and the inner member, a foot free to move within limits in two directions relatively to the leg and a resilient member between the lower extremity of the leg and the foot.

13. The combination with a vehicle or transporter of a carrier rotatable in a "horizontal plane", feet supported on trunnions in said carrier and movable vertically relatively thereto, a cam-rail engaging with said feet and so shaped that if the carrier rotates at a uniform velocity the transporter will move over the ground at a uniform rate without slip between the feet and the ground.

14. The combination with a vehicle or transporter of a carrier rotatable in a "horizontal plane", feet supported on trunnions in said carrier and movable vertically relatively thereto, friction rollers on the feet, a cam-rail engaging with the friction rollers and so shaped that if the carrier rotates at a uniform velocity the transporter will move over the ground at a uniform rate without slip between the feet and the ground.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

HENRY SELBY HELE-SHAW.

Witnesses:
ALFRED J. BOULT,
HARRY B. BRIDGE.