July 29, 1952 J. MacVEIGH 2,604,857

RAILWAY VEHICLE

Filed March 10, 1948 3 Sheets-Sheet 1

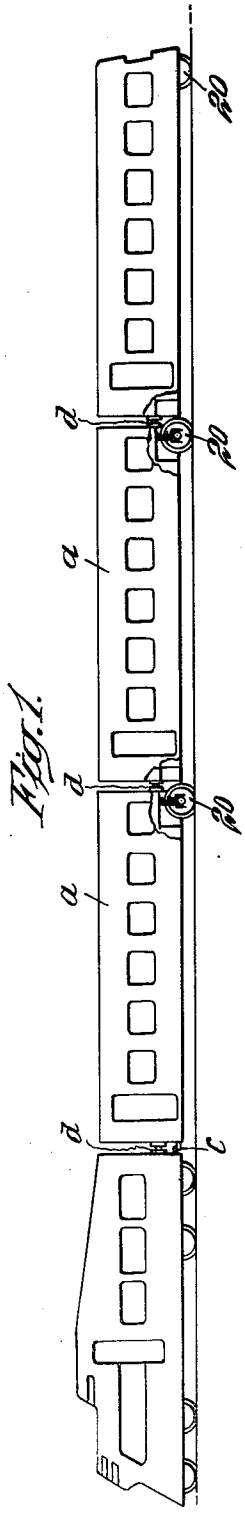


Fig. 1.

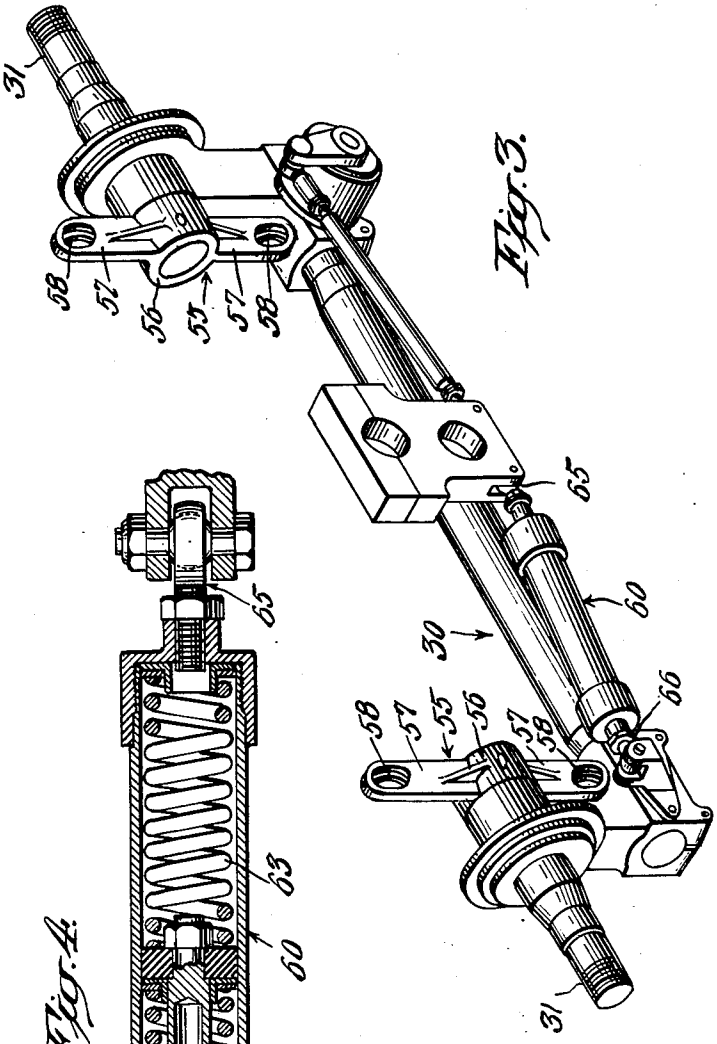


Fig. 3.

Fig. 4.

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RAILWAY VEHICLE

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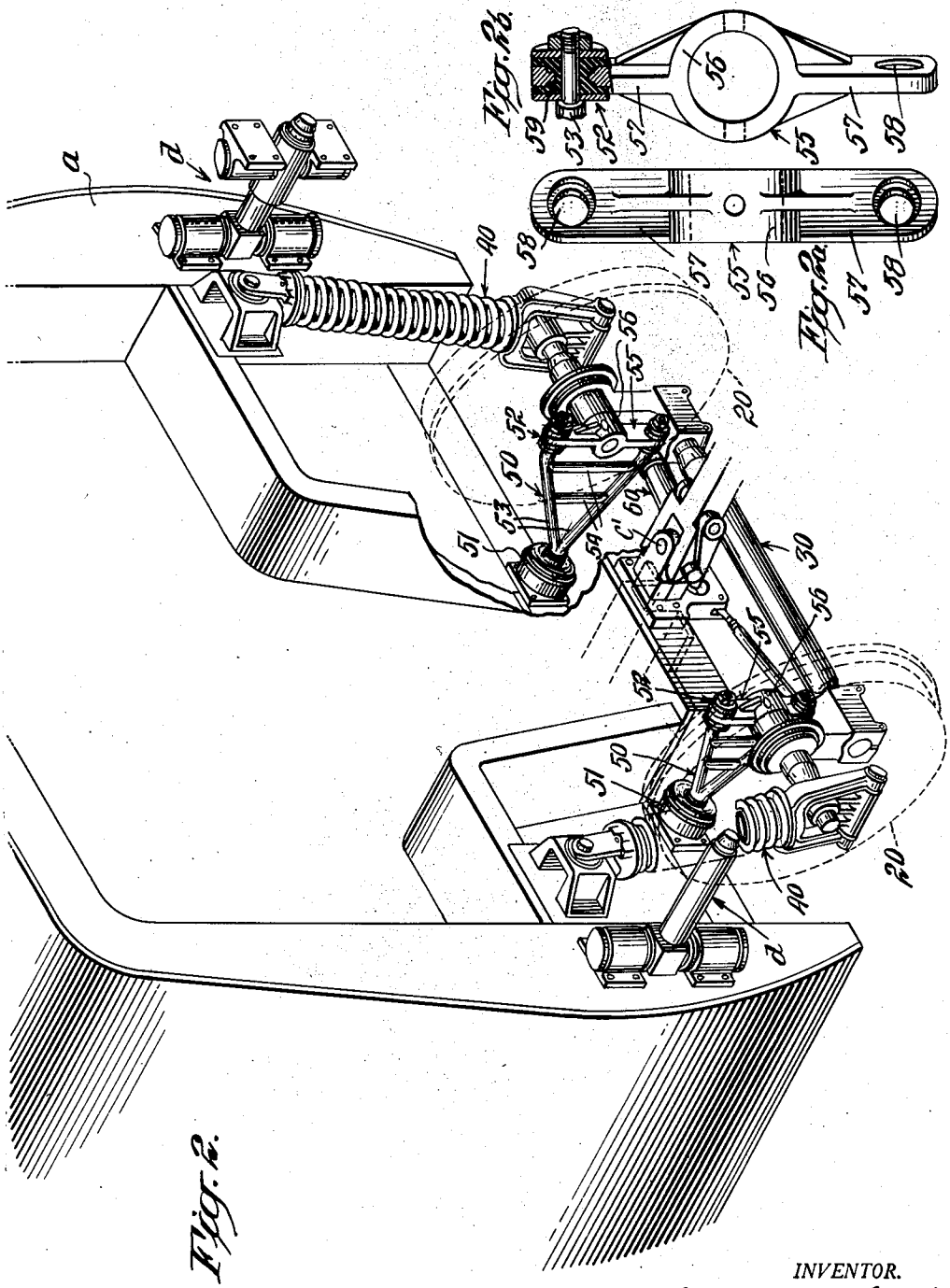


Fig. 2.

Fig. 2a.

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RAILWAY VEHICLE

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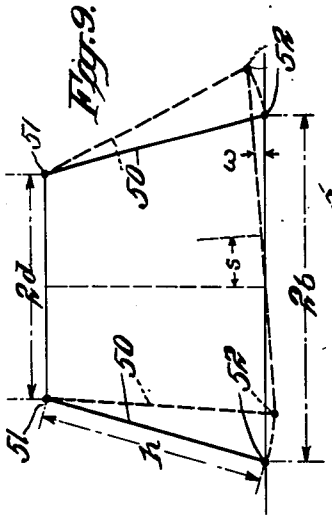


Fig. 9.

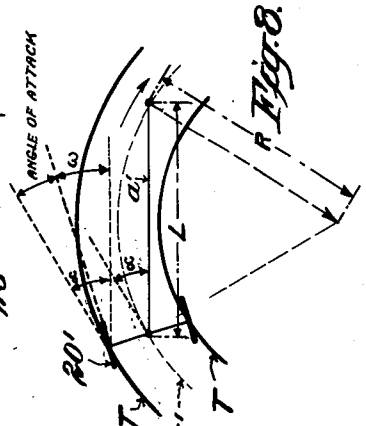


Fig. 8.

Fig. 7.

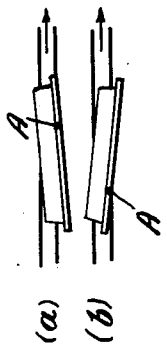


Fig. 6.

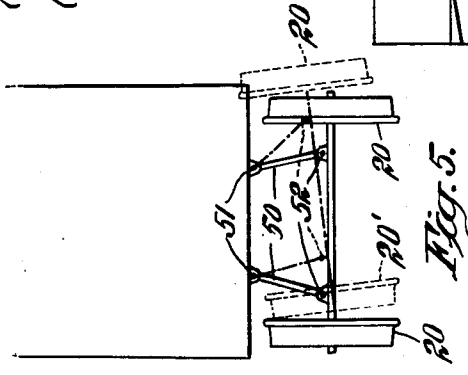


Fig. 5.

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UNITED STATES PATENT OFFICE

2,604,857

RAILWAY VEHICLE

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Application March 10, 1948, Serial No. 13,970

3 Claims. (Cl. 105—4)

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This invention relates to railway vehicles and aims to provide a railway car of normal length and light construction which may be drawn at high speed without danger of derailment.

In ordinary railway vehicle construction, a long car is mounted at its ends on four-wheel bogies which are pivoted to the car body and therefore unguided. The front outer wheel of each bogie attacks the track at a positive angle when the vehicle is rounding a curve, bringing the leading edge of its flange into contact with the rail so that the friction between the flange and the rail tends to cause the wheel to mount the rail. This tendency is counteracted only by the weight of the vehicle. By guiding the wheels it is possible to make the outer wheel attack the track at a curve at a negative angle, bringing the trailing edge of its flange into contact with the rail so that the friction between the flange and the rail tends to hold the wheel down on the rail and thus makes it unnecessary to rely on the weight of the vehicle as a means for avoiding derailment. It can be shown mathematically, as hereinafter explained, that the greatest factor of safety against derailment is obtained when the outer wheel attacks the track at a small negative angle—an angle of about —25 minutes of arc.

Guiding of the wheels to attack the track at a negative angle of —25 minutes of arc on "most dangerous" curves has been obtained in trains of cars each of which has only one pair of wheels which are located at its rear end with their axis perpendicular to the axis of the car. In such trains, it is necessary to make the cars very much shorter than those customarily used on railroads, as pointed out in U. S. Patent No. 2,462,666, issued February 22, 1949, to Patentes Talgo, S. A. If the cars have a length substantially greater than six times the gauge of the track, the negative angle at which the outer wheels attack the track at a curve is materially greater than —25 minutes of arc, so that maximum safety against derailment is not obtained, and, furthermore, there is an objectionable increase in the tractive effort necessary to draw the train.

The object of my invention is to permit lengthening the cars of such a train while at the same time avoiding the difficulty which has heretofore made it necessary to use cars not greatly exceeding six times the gauge of the track. In accordance with my invention, the angle between the axis of a pair of wheels at the rear end of a car and the axis of the car

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is varied by the centrifugal force which acts on the car in rounding curves and this variation is limited so that the burdened wheel attacks the track at a small negative angle.

In order that my invention may clearly be understood, I will describe the construction of an illustrative railway vehicle embodying my invention and illustrated in the accompanying drawings, and will then explain in detail the operation of this vehicle on rounding a curve.

In the accompanying drawings:

Fig. 1 is a partial side view of a train of railway cars embodying my invention;

Fig. 2 is a perspective view of the rear end of one of the cars;

Fig. 2*a* is a side view and Fig. 2*b* a face view of a fitting on the dead axle to which a radius rod is attached;

Fig. 3 is a perspective view of the dead axle taken from the side opposite to that shown in Fig. 2;

Fig. 4 is an enlarged sectional view of the horizontal spring strut;

Fig. 5 is a diagrammatic plan view of the rear portion of one of the cars;

Fig. 6 is a diagram showing the action of a wheel at an angle to a rail indicating at (*a*) a positive angle of attack, and at (*b*) a negative angle of attack;

Fig. 7 is a graph indicating the relation between the angle of attack and the factor of safety against derailment;

Fig. 8 is a diagram showing the relation between the axis of the car and the track at a curve; and

Fig. 9 is a diagram of the geometry of the radius rod arrangement.

In the drawings the angles between the radius rods and the axis of the car and between the wheels and the track are greatly exaggerated for the sake of clearness.

The train shown in the drawing consists of a number of cars each having a rigid car body *a* with traction connections *c* each including a vertical pivot c_1. The weight of the front end of each car body is carried on the rear end of the preceding car body by sliding lateral connections *d*. A pair of wheels **20** is located at the rear end of each car body *a* near one of the traction pivots c_1. The wheels **20** of each pair of wheels are mounted on stub shafts **31** forming part of a dead axle **30**.

The weight of the rear portion of each car is carried on its dead axle **30** by a spring suspension which is formed to permit lateral move-

ment of the axle with respect to the car body. In the form shown, the spring suspension takes the form of substantially vertical spring struts **40** with universal joints at their ends. Relative lateral movement of the car body and the wheels is resisted and limited by a horizontal spring strut **60** containing balanced compression springs **63, 64**. The strut **60** is connected to the car body and to the dead axle **30** by universal joints **65, 66**. The strength of the compression springs **63, 64** is so proportioned to the weight of the vehicle that the centrifugal force developed in rounding a curve at high speed brings the turns of the burdened spring into contact with each other. In the illustrative car this allows a lateral displacement of the wheel axle with respect to the car body of 1.33 inches.

The angle between the axis of the wheels **20** and the axis of the car body is controlled by a pair of radius rods **50**. In the form illustrated, each radius rod **50** consists of a V-shaped frame having side members **53** secured together by cross-pieces **54**. The side members **53** of each rod **50** converge at the inner end of the rod which is secured to the car frame by a universal joint **51**. The outer ends of the side members **53** are secured to fittings **55** mounted on the inner ends of the stub shafts **31** of the dead axle **30**. Each fitting **55** has a collar **56** pinned on one of the stub shafts **31** and a vertical bar **57** having transverse holes **58** in its upper and lower ends. These holes are recessed and contain spool-shaped rubber blocks **59** through which the outer ends of the side members **53** of the rod **50** extend. The rubber blocks **59** are clamped between washers on the end portions of the side members **53** so that they form a joint or pivot **52** on which the rod **50** may turn with respect to the axle **30**.

An important feature of the invention consists in placing the universal joints or pivots **51** between the rods **50** and the car frame closer together than the pivots **52** between the rods and the axle, so that, when the wheels **20** are in their normal position, the radius rods form with the car body and axle a trapezoid having its longer end at the axle (Fig. 5). The difference between the distance separating the pivots **51** and the distance separating the pivots **52** depends upon the length of the car.

The operation of the car which has been described will now be explained.

The terms "positive" and "negative" angle of attack are used to define a relation between a flanged wheel and a rail when the rolling direction of the wheel is not exactly parallel to the rail. When the rolling direction of the wheel is inclined toward the rail from the side of the rail engaged by the flange on the wheel, as shown at (*a*) in Fig. 6, the wheel is said to attack the rail at a positive angle. When the rolling direction of the wheel is inclined away from the rail toward the side of the rail which is engaged by the flange of the wheel, as shown at (*b*) in Fig. 6, the wheel is said to attack the rail at a negative angle. When a burdened wheel (that is one whose flange is being forced against the rail) attacks the rail at a positive angle, friction between the front portion of the wheel flange and the rail tends to make the wheel mount the rail, while, when a burdened wheel attacks the rail at a negative angle, friction between the rear portion of the flange and the rail tends to hold the wheel on the rail. (See Fig. 6 in which the contact points between the flanges and the rails are indicated at A).

In textbooks dealing with railroading, danger of derailment is considered in connection with the Nadal safety factor

$$\frac{S}{Q}$$

This factor represents the ratio of side thrust that a wheel can stand to the weight bearing on the wheel. The greater this factor, the less the danger of derailment.

Fig. 7 shows three curves in which the safety factor

$$\frac{S}{Q}$$

is plotted as a function of the angle of attack for each of three wheel diameters, namely, 600, 800 and 1,000 mm. These curves show that the safety factor is much larger for negative than for positive values of the angle of attack and indicate also that the maximum value of the safety factor where danger of derailment is least occurs at an angle of attack of −25 minutes of arc.

When the car which has been described is rounding a curve at high speed, centrifugal force throws the car body outward displacing it laterally from the wheels **20** to the extent permitted by the strut **60**. As shown in Fig. 5, this has the effect of swinging the axis of the wheels **20** out of its normal perpendicular relation to the axis of the car body. The burdened wheel **20'** is, therefore, inclined outwardly with respect to the axis of the car to an extent depending on the spacing of the pivots of the radius rods. (See dotted line position in Fig. 5*b*.)

The axis *a'* of the car forms a chord of the median arc T' of the curved track T so that it is inclined inwardly from the track at the rear end of the car to an extent depending on the relation between the length of the car and the radius of the curve in the track (Fig. 8).

The angle at which the burdened wheel attacks the track is the difference between the angle α which the axis of the car makes with the track at the rear end of the car and the angle ω between the wheel and the axis of the car (Fig. 8). As the first angle depends upon the length of the car and the second angle on the difference between the spacing of the radius rods at their two ends, it follows that for any car length the spacing of the pivots of the radius rods may be made such as to give the burdened wheel the small negative angle of attack which gives the greatest safety. This result is attained in a car of normal length—say 46 feet—by putting the pivots **52** at the outer ends of the radius rods 4 inches further apart than the pivots **51** at their inner ends.

It is apparent from Fig. 8 that the relation between the angle α between the axis *a'* of the car and the direction of the track at the rear end of the car when the train is rounding a curve, the length L of the car and the radius of curvature R of the track is:

$$\sin \alpha = \frac{L}{2R}$$

Since the car-length is 46 feet and the radius of curvature of the most dangerous curves on ordinary railroads is about 1400 feet, this formula shows that in rounding such curves the axis of the car will be inclined inwardly at an angle of 57 minutes of arc to the track at the rear end of the car.

From the geometry of the radius rod arrangement (Fig. 9), and considering only the small rotations of the radius rods which will actually take place so that the arcs, sines and tangents of the angles may be considered equal, it is simple to prove that the angle ω between the wheels and the car axis (which is the same as the angle ω between the axis of the wheels and a perpendicular to the car axis) is given by the following formula:

$$\omega=\frac{S(b-d)}{hb}$$

where S is the lateral displacement of the car body relative to the wheels, d is half the distance between the pivots **51**, b is half the distance between the pivots **52**, and h is the length of the radius rods. In the illustrative car embodying my invention, the lateral displacement S allowed by the spring strut **60** is 1.33 inches, the length of the radius rods h is 13.5 inches, and the pivot points **52** are 4 inches further apart than the pivot points **51**, d being 20 inches and b 22 inches. Consequently, by the above formula, ω is 32 minutes of arc.

The angle at which the burdened wheel attacks the track is, therefore, 57'' minus 32'', or 25 minutes of arc, which is the same angle of attack as is obtained in the construction shown in Patent No. 2,462,666 when the car sections have a length of twenty feet or four times the width of the gauge. This angle gives the maximum factor of safety.

What I claim is:

1. A railway train comprising articulated car bodies, a running gear for each car body including a pair of wheels and an axle, a supporting connection between the rear end of each car body and its running gear formed to permit relative lateral movement between the car body and the running gear, resilient means connected to the running gear and the car body to oppose lateral movement of the body away from a central position in relation to the running gear with a force less than the centrifugal force of the body in rounding a curve at high speed, a guiding connection between the running gear and the car body actuated by the lateral movement of the car body in rounding a curve at high speed to turn the wheels of the running gear towards a position parallel to the tangent to the curve, and stop means associated with the body and the running gear and so related that they arrest the relative movement between the body and the running gear in rounding a curve before the wheels of the running gear become parallel to the tangent to the curve.

2. A railway train comprising articulated car bodies, a running gear for each car body including a pair of wheels and an axle, a supporting connection between the rear end of each car body and its running gear formed to permit relative lateral movement between the car body and the running gear, resilient means connected to the running gear and the car body to oppose lateral movement of the body away from a central position in relation to the running gear with a force less than the centrifugal force of the body in rounding a curve at high speed, a guiding connection between the running gear and the car body actuated by the lateral movement of the car body in rounding a curve at high speed to turn the wheels of the running gear towards a position parallel to the tangent to the curve, and stop means associated with the body and the running gear and so related that they arrest the relative movement between the body and the running gear in rounding a curve when the wheels of the running gear are at an angle of 25 minutes of arc to the tangent of the curve.

3. A railway train comprising articulated car bodies, a running gear for each car body including a pair of wheels and an axle, a supporting connection between the rear end of each car body and its running gear formed to permit relative lateral movement between the car body and the running gear, resilient means connected to the running gear and the car body to oppose lateral movement of the body away from a central position in relation to the running gear with a force less than the centrifugal force of the body in rounding a curve at high speed, a guiding connection between the running gear and the car body consisting of horizontal radius rods pivoted to the car body at spaced points in advance of the wheels of the running gear and to the running gear at more widely spaced points so that the lateral movement of the car body in rounding a curve at high speed turns the wheels of the running gear towards a position parallel to the tangent to the curve, and stop means associated wtih the body and the running gear to limit the relative movement between the body and the running gear.

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