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Leger

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[54] **METHOD AND APPARATUS FOR TRANSFERRING ELECTRICAL ENERGY TO HIGH SPEED APPARATUS**

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[51] **Int. Cl.** **B60l 5/24**
[58] **Field of Search**.......191/54–56, 64–70; 92/162 P

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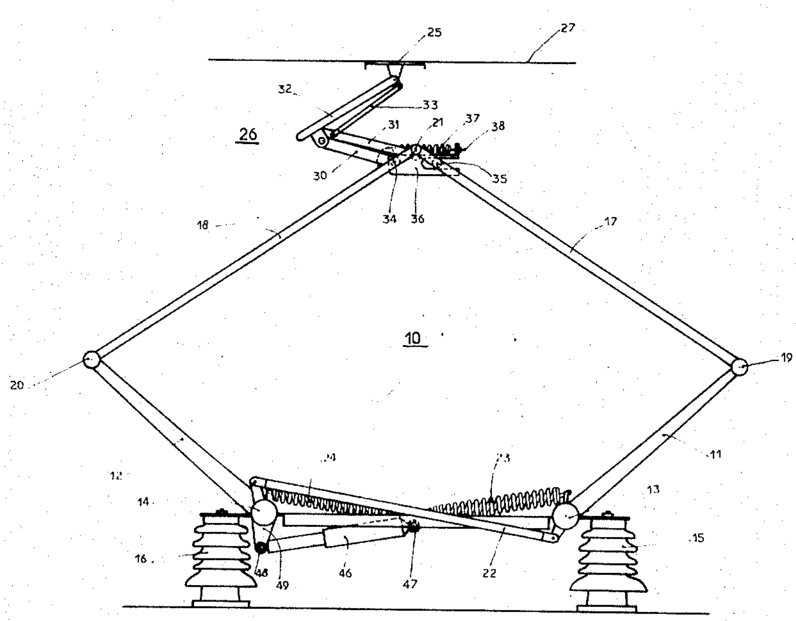
[57] **ABSTRACT**

An electrical pickup to be carried by a high speed vehicle for transferring energy from a catenary system to the vehicle. The apparatus includes two separate structures which separately accommodate high frequency, low amplitude displacements and low frequency, high amplitude displacements between the high speed vehicle and a moving bow which is carried by the vehicle and slides on the catenary.

20 Claims, 8 Drawing Figures



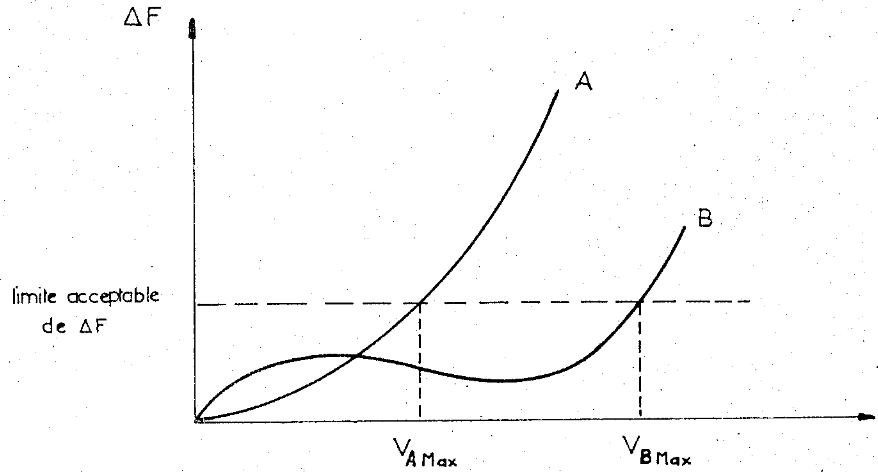


FIG. 1

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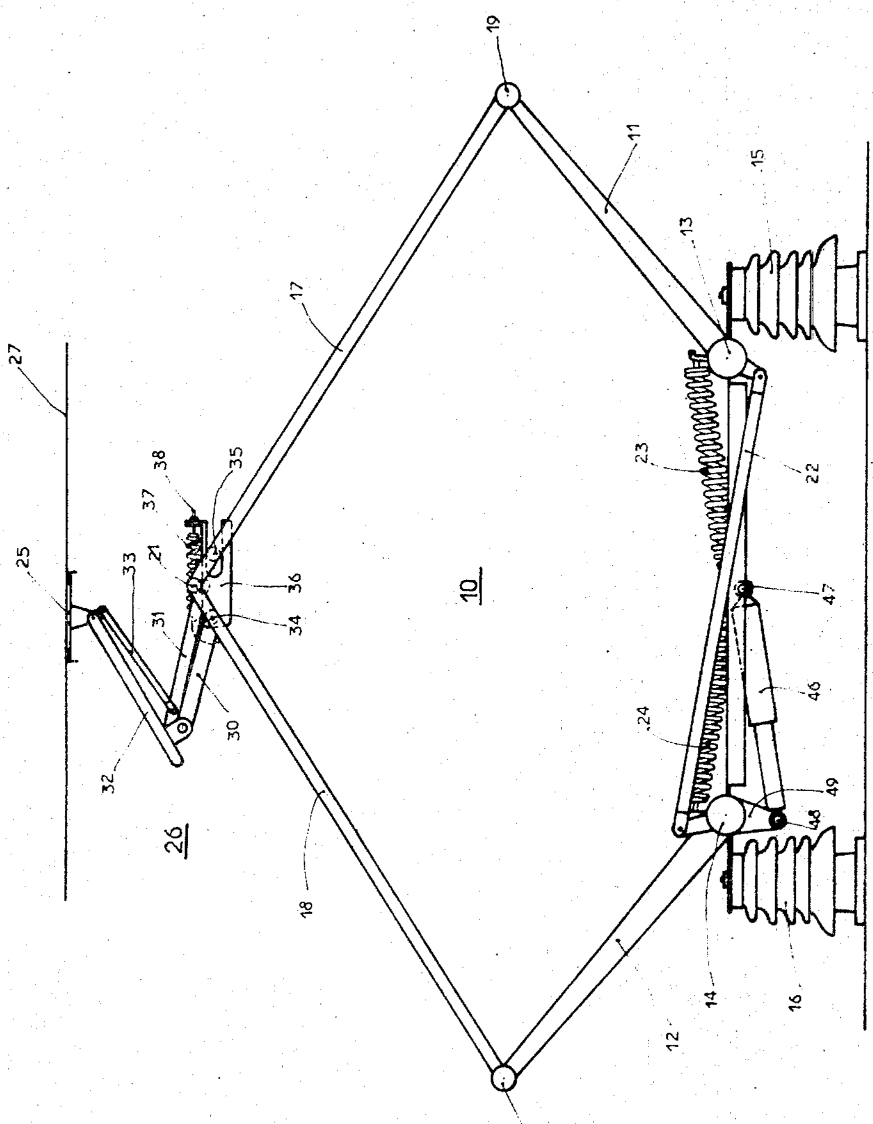

FIG. 2

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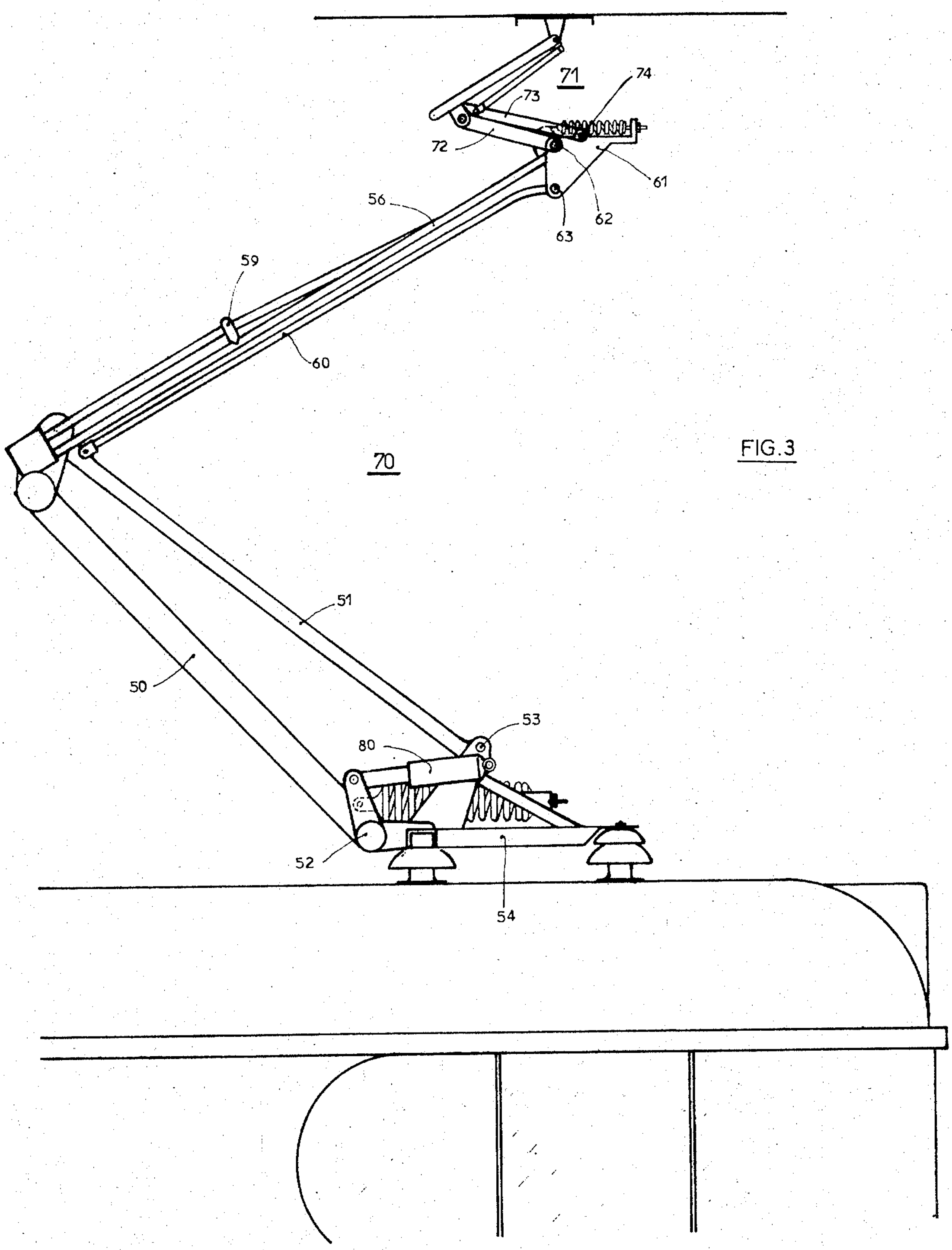


FIG. 3

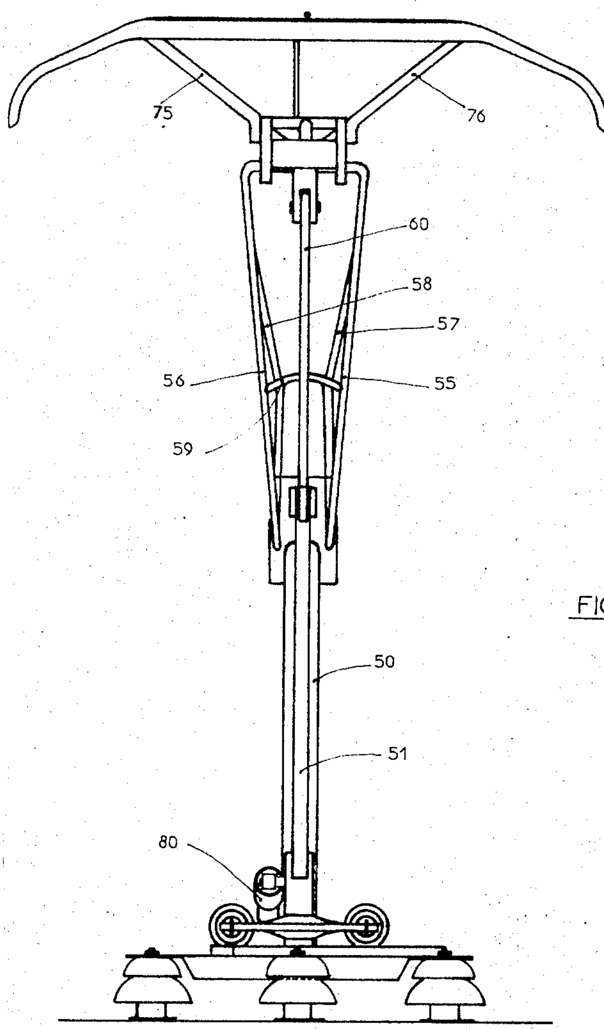


FIG. 4

FIG. 5

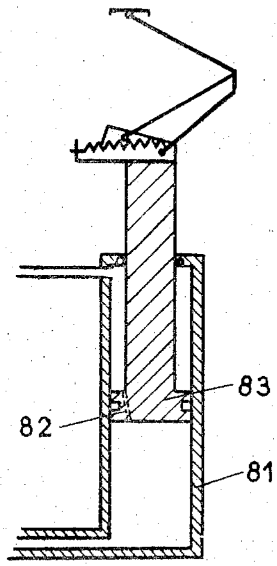


FIG. 6

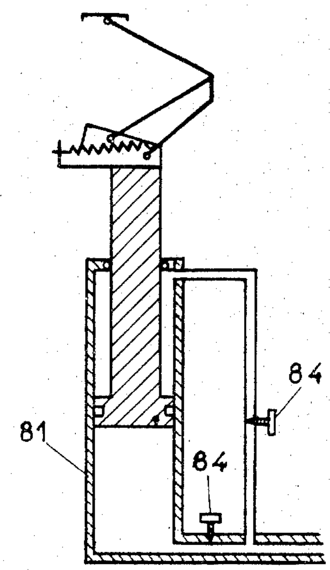


FIG. 7

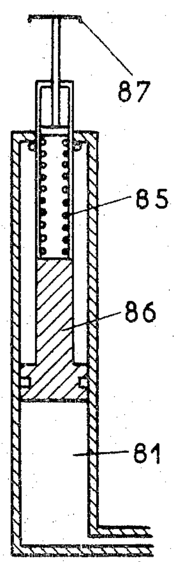
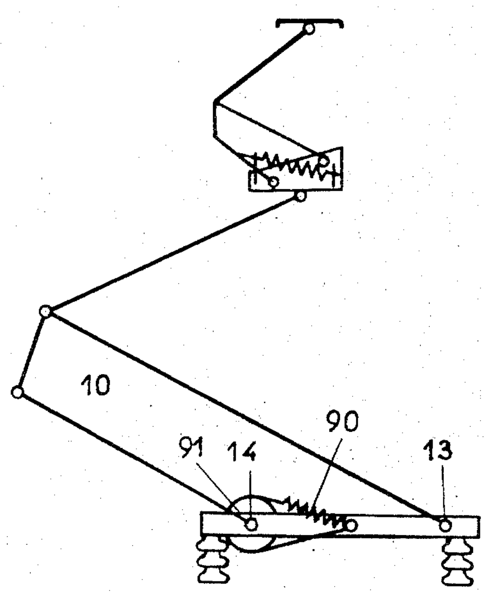


FIG. 8



METHOD AND APPARATUS FOR TRANSFERRING ELECTRICAL ENERGY TO HIGH SPEED APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to the field of electrical energy pickups and is more particularly directed to improvements in current collection devices for electrically driven, rail vehicles. The improvements are intended to permit the feeding of electrical energy to such vehicles at substantially higher vehicle speeds than those permitted by prior systems.

2. Description of the Prior Art

It is known that the present current collection devices, commonly taking the form of pantographs intended to transfer electrical energy to electrically driven locomotives, are essentially composed of an articulated lower structure fixed to the roof of the locomotive and friction bands or shoes and their accessories constituting the actual current collector which are generally linear in configuration for the powers concerned. The articulated lower structure generally supports the friction bands through a medium of elastic suspension components.

The lower structure allows the current collector, generally called the bow, to move into contact with the catenary for the purpose of placing the pickup into service. Also, the lower structure enables the bow to remain in contact with the catenary during operation regardless of the variations in height of the catenary such as the increased height at level crossings and reduced height in tunnels.

The articulated structure comprises a set of springs and cams so designed that the static contact force applied upwardly by the bow against catenary will remain as constant as possible regardless of the height of the catenary. Hence the structure is termed an "astatic structure." As an example, contact force is adjusted on many railway lines to a value of approximately 7 kilograms.

In the currently known support structures generally referred to as pantographs, the elastic suspension of the bow is stiff with the spring constants being in the order of 10 kilograms per centimeter and the overall stroke being short, in the order of few centimeters. The stroke is thus far shorter than the variation in sag or droop of the catenary wires between two successive supports along the catenary.

The current pickup properties of a pantograph are closely dependent upon the movable mass of the whole pantograph. The movable mass is naturally dependent on the difference between the maximum and minimum current pickup heights, this difference in height, otherwise than in exceptional cases, being in the order of 2 meters to 2.5 meters.

The height difference defines the deflection which the pantograph must accommodate and, consequently, for a given kinematic system, the dimensions of the component parts of the pantograph. Since the dimensions are fixed, the mass is determined by considerations of mechanical strength and it is obvious that a certain minimum must be maintained if the sturdiness of the apparatus during operation is not to be jeopardized.

It has been recognized for a long time that the masses, particularly that of the lower structure, could be reduced by varying the kinematics. In this connection, a single-leg, Y-shaped, semi-pantograph has been produced which represents a considerable step forward in the art.

The contemplated increase in maximum speeds toward 300 kilometers per hour or more makes it necessary at the present time to reconsider the problem of current collection from a catenary.

One difficulty encountered is that all catenaries have certain elasticity which varies from one catenary to another. The lift produced by the static force applied by the pantograph is less at the points of suspension of the catenary than at points near the center of the catenary span. This variation in lift has the effect of requiring the pantograph as it moves under the catenary to displace up and down as the pattern of the catenary can be regarded as a sinusoid, the frequency of which is proportional to the speed of the locomotive.

In the course of traversing the sinusoidal catenary, the force applied by the pantograph varies about a fixed mean or static value. For a given catenary, the greater the mass of the movable part of the pantograph and the higher the speed of the locomotive, the greater the variation about the mean.

It is therefore evident that starting from a certain speed, the periodic variation of the applied force attains and then exceeds the static force. The result is, firstly, poor current collection and, secondly, loss of contact accompanied by arcing.

In order to minimize the disadvantages of the variations in pressure, it is known to increase the static force by a force of aerodynamic origin. The aerodynamic force depends upon the magnitude of the mass of the articulated system. This method, however, has the disadvantage of simultaneously increasing the lift and deformation of the contact wire in the catenary.

The addition of a single or double action shock absorber to the lower structure, which is sometimes recommended, has in some cases enabled current collection to be improved slightly.

Nevertheless, these various means in practice do not permit satisfactory current collection at speeds higher than 200 kilometers per hour.

In a different vain, published tests indicate that improvements in current collection have been attempted by modifications to the catenary. The modifications consisted of spacing of the support masts more closely, increasing the mechanical tension, utilizing springs to support the catenary at the mast support points and increasing the number of intermediate support points between two successive masts. All of these modifications, even if applied simultaneously, lead to only mediocre results, despite the fact that the tests were carried out only up to 150 kilometers per hour. Additionally, the costs of such modifications may be prohibitive.

With regard to the attainment of 300 kilometers per hour, the application of such improvements to the catenary would be highly speculative. It is admitted that further improvement of the current collection process will be necessary in the area of the pantograph, particularly in attempting to lighten the current collection head although it appears that the limit of possibilities has already been obtained in this area.

In the present invention, the task of improving current collection originated in a complete reappraisal of the problem. Generally, the problem breaks down into two basic areas:

1. Low amplitude displacement due to movement of the vehicle carrying the current collection device, particularly as a result of the flexibility of the catenary and its method of support. This displacement has an order of magnitude of ±15 centimeters at present speeds of 150 kilometers per hour.

2. Displacements of greater amplitude which are encountered when the catenary changes height at grade crossings or in tunnels, that is, displacements due to the static profile of the catenary. Here the displacements have an order of magnitude between 2 meters and 2.5 meters.

SUMMARY OF THE INVENTION

In the present invention, separate apparatus are allocated to solving each of the above-referenced problems.

The first current collection apparatus is adapted to follow slight variations due to the flexibility of the catenary. It will therefore be possible for the first apparatus to have considerably smaller dynamic mass than that of the usual pantograph and its movements will not lead to substantial variation in force in relationship to the static force, the pressure which is applied by the apparatus to the catenary when the apparatus is at rest.

The small dynamic mass of the first apparatus permits current collection with very low aerodynamic correction and, in certain cases, without any aerodynamic correction at all. Accordingly, there is a considerable reduction in the lifting and deformation of the contact wire. Current collection is accomplished under good conditions at very high speeds.

A second apparatus supports the first apparatus in order to permit current collection at catenary heights approximating the mean static height of the catenary. In other words, slight variations due to the flexibility of the catenary do not affect the second apparatus. The second apparatus is capable of lowering itself or of being lowered so that the first apparatus can continue to pickup current correctly when the static profile of the catenary is reduced, for example, in tunnels or under bridges. The second apparatus can also raise itself or be raised so that the first apparatus continues to pickup current from the catenary when the static profile of the catenary is increased, for example, at grading crossings.

The present invention advantageously combines the two separate pickup arrangements.

According to one embodiment, each apparatus is a conventional pantograph and, in particular, a semi-pantograph of the singe-leg type which, for a given design, insures minimum dynamic mass.

The lower apparatus may well be an elevating platform or a simple vertical jack.

The upper apparatus may be a spring box (or two spring boxes if required to support a bow) provided that the spring or springs are capable of providing sufficient deflection to follow slight variations in height caused by the flexibility of the catenary.

BRIEF DESCRIPTION OF THE DRAWINGS

The novel current collection device together with its numerous objects and advantages will be described and better understood by reference to the following drawings in which the same elements bear the same reference numerals throughout the several figures.

FIG. 1 shows by way of example a diagram in which locomotive speeds V are shown on the abscissa and variations in force ΔF applied to the catenary on the ordinate.

FIG. 2 is an elevation view of one embodiment of the invention having a conventional pentagonal pantograph as the lower structure and a semi-pantograph of the single-leg type as the upper structure.

FIG. 3 is an elevation view of another device for carrying out the present invention with a conventional semi-pantograph as the lower structure. Again the upper structure is a semi-pantograph of the single-leg type.

FIG. 4 is a front elevation view of the device illustrated in **FIG. 3**.

FIG. 5 illustrates diagramatically a modified embodiment of the present invention in which the second support is a hydraulic or pneumatic jack having a calibrated outlet.

FIG. 6 illustrates diagramatically another modification of the embodiment shown in FIG. **5** wherein the supply lines of the jack have adjustable orifices.

FIG. 7 illustrates diagramatically still another modification of the embodiment shown in FIG. **5** wherein the bow is supported elastically by a spring rod housed within the stem of the jack.

FIG. 8 illustrates diagramatically another embodiment of the present invention similar to that illustrated in FIG. **2** but provided with a friction brake on the lower support structure.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 shows a diagram in which locomotive speed V is compared with the variation in force ΔF applied to the catenary by two different pantograph systems. Curve A represents the forces applied by the conventional pantographs known in the prior art. It will be noted that the conventional pantograph at a speed $V_{A\,Max}$ reaches the upper acceptable limit of the force ΔF represented by the horizontal dotted line. The second curve B is unusual and quite different from curve A. Curve B represents the forces obtained by modifying the stiffness of the bow support springs and damping coefficients of the pantograph in accordance with the present invention. It is readily apparent that the acceptable limit of the force ΔF is reached at a speed $V_{B\,Max}$ which is substantially higher than that obtained with the conventional pantograph systems.

In FIG. **2** the conventional pentagonal pantograph is identified generally by the reference **10**. The pantograph **10** comprises two links **11** and **12** articulated at **13** and **14** on insulators **15** and **16** respectively and upper connecting rods **17** and **18** articulated respectively at **19** and **20** on the links **11** and **12**. Connecting rods **17** and **18** are pivotally joined at the apex **21**. Connecting rod **22** is an interlocking rod which equalizes the movements of the two parts of the pantograph so that the apex **21** always moves along a vertical line with respect to the horizontal mount of the pantograph.

Springs **23** and **24** support the pantograph **10** resiliently. The conventional hydraulic or pneumatic jack for controlling the raising or lowering of the pantograph is not shown in the drawings. While in the known pantographs, the shoe or bow **25** is supported elastically by the pantograph **10**, in the present invention bow **25** is supported by the medium of a small pantograph designated generally at **26**. The small pantograph **26** is shown as a single-leg, semi-pantograph type which has been in use throughout the world for many years.

As is known, a pantograph of the single-leg type comprises a link **30** and a counter-link **31**. Links **30** and **31** are pivoted on a common connecting rod **32** and associated with a guide connecting rod **33** which guides the bow to prevent the bow from tipping when not in contact with the catenary. Link **30** is pivoted at **34** on the connecting rod **18** while the counter-link **31** is pivoted at **35** by a pin which slides in a sliding guide **36** joined to the connecting rod **18** by, for example, welding. A spring **37** supports pantograph **26**. Spring **37** at one end operates on either link **30** or counter-link **31**. At the other end, spring **37** is fixed to the angled bracket **38** which is in turn fastened to slide guide **36**. Lastly, a shock absorber **46** is connected at one end **47** to a point which is fixed in relation to the mounting insulators **15** and **16** while the other end is fixed to the crank **49** fixedly joined with the pantograph link **12**. According to the present invention, the small pantograph **26** is designed for small amplitude displacements due to the flexibility of the catenary **27**. The amplitude of these displacements are known for existing catenaries and can be easily determined with accuracy for proposed catenary systems.

In the embodiment of the invention illustrated in FIGS. **3** and **4**, a conventional semi-pantograph is disclosed. The semi-pantograph, designated **70**, is comprised of a link **50** and counter link **51** pivotally mounted respectively at pivot points **52** and **53** along the insulated mounting frame **54**.

The distal extremeties of link **50** and the counter link **51** are pivoted at separate points on a common connecting rod which has two branches indicated by reference numerals **55** and **56** (FIG. **4**). The connecting rod is preferably bent over at the pivot point with the counter link **51**.

The systems of connecting rods **55** and **56** may be reinforced by a number of different stiffeners such as links **57** and **58** which in turn include a brace **59**.

It is also possible to provide a guide connecting rod **60** which controls the position of angle plate **61**. The pivot points **62** and **63** define the fourth side of the quadrilateral linkage. The side **62–63** is preferably displaced parallel to itself during vertical movement as is known.

The above-described arrangement of linkages compose a semi-pantograph **70** of the type which is conventional. The semi-pantograph **70** supports a small pantograph, generally designated **71**. The small pantograph **71** is the same as semi-pantograph **26** described in FIG. **2**.

As shown, link **72** is pivoted on angle plate **61** at pivot point **62** while the counter-link **73** is pivoted at point **74** on the angle plate **61**. The shock absorber system **80** is arranged to operate from a crank connected with link **50**. The operation of the shock absorber is the same as that described in connection with absorber **46** in FIG. **2**.

From a constructional point of view, it is to be noted that the connecting rods **55** and **56** as seen in FIG. **4** are much closer to one another and form a much smaller angle between one another than is usually the case in conventional semi-pantographs. The stability of the bow is obtained by means of two similar connecting rods **75** and **76** which form a part of the small pantograph **71**. It should be observed that it is not possible for both of the interconnected pantographs to be astatic, that is, the pantographs cannot include an arrangement of springs such that each pantograph applies a force to the catenary which is independent of the design height of the structure.

In a preferred embodiment, only the lower articulated system is astatic.

The lower astatic structure may also be composed of a vertically positioned hydraulic piston and cylinder assembly or pneumatic jack **81** (FIG. **5**) which is supplied from a constant source of pressure.

With the jack **81**, shock absorption may be accomplished internally, for example, by providing a calibrated outlet orifice **82** in piston **83** (FIG. **5**) or externally by providing adjustable orifices **84** on the jack supply lines (FIG. **6**).

Where a vertical jack is used, as in FIG. **7**, bow **87** may be suspended either by means of a single-leg pantograph or by means of a coil spring **85** and telescoping rod accommodated coaxially within the piston rod **86** of the jack as shown.

FIG. **8** illustrates diagramatically an apparatus similar to that illustrated in FIG. **2** but provided with a friction brake in the form of a brake band.

For the sake of clarity, all parts in FIG. **2** included between the pivot point **13** and **14** such as components **22–24** and **47–49**, have not been shown in FIG. **8**. Shock absorber **46** is replaced by a conventional band brake **90** operating on pulley **91**. Pulley **91** is keyed to a shaft (not visible) for rotation and the shaft is rotated by an actuating motor (not shown) to control the raising of the second or lower support **10**.

The mechanical tension of band brake **90** is adjusted so that the lower support **10** operates only at the end slightly before the end of the downward displacement of the first or upper support.

In conventional pantograph construction, it is generally considered advantageous for drive friction to be kept as low as possible, that is, in the lower, astatic structure the addition or removal of a weight in the order of few tens of grams, a very light weight, should bring about a downward or upward displacement of the structure respectively. The introduction of drive friction widens the hysteresis curve of the structure and in such case the weight resulting in movement may amount to several kilograms. The present construction including the friction brake therefore runs counter to the teachings of the prior art and is made possible by the present invention.

In conjunction with the present invention which leads to a modification of the suspension for the electrical pickup of bows and more generally to the heads of the conventional pantographs so that the pantographs have unusual deflection characteristics, it has been discovered that a special selection of characteristics correlated with the ranges of stiffness for the suspension and the damping coefficient, it is possible to increase the normal operating speed of the pantograph in a given manner with good conditions of current collection.

In accordance with the present invention described above, the pantograph is comprised of lower astatic elevating structure associated with a shock absorber having a shock absorption coefficient C expressed in kilogram-seconds per centimeter, a bow of unusual shape or structure, and an elastic suspension having a stiffness K expressed in kilograms per centimeter between the bow and elevating structure. The pantograph in assembled form has a stiffness K which is lower than the stiffness usually employed, that is less than one kilogram per centimeter and the value of the shock absorption coefficient is no less than 0.2 or greater than 0.8.

With this range of values for the characteristics of the pantograph, it is possible to produce excellent current collection conditions up to speeds twice as high as those suitable for the usual pantographs. The pantographs of the present invention may be utilized with simple catenaries which are less costly to construct.

It is a characteristic of the device according to the present invention that the pantograph may be selected and designed for a well defined catenary, that is a catenary having not only large variations in height in the static condition but also having slight sinusoidal variations in height due to movement of the current collection apparatus along the catenary. The sinusoidal amplitude may be easily determined for existing catenaries and can be readily calculated for proposed catenaries.

Furthermore, for carrying out the present invention, the known suspension devices for mounting the bow to the top of the upper apparatus may be advantageously retained.

The performance of the apparatus in the present invention requires that measures be taken to ensure that the vibratory movement of the upper apparatus does not give rise to movement of the lower apparatus as long as the movements of the bow or friction element do not exceed the amplitude that can be absorbed by the upper apparatus.

While the present invention has been described in a number of different embodiments, it should be understood that various modifications and substitutions can be made without departing from the spirit of the invention. For example, the lower apparatus may be normally locked in the extended position. Limit detectors mounted to the upper apparatus may be provided at the deflection limits of the upper apparatus to unlock the lower apparatus. Where the lower apparatus incorporates a static friction device, a device may be used to ensure that movements of the lower apparatus do not go beyond an average range. The lower apparatus may alternately contain a shock absorber which modifies the transfer function of the support and the shock absorber may be particularly advantageous where there is a danger of resonance or the lower apparatus is of the astatic type. The lower apparatus may also be servo controlled by movements of the upper apparatus. The servo control may be linear and have a band pass which is designed so that the rapid movement of the upper apparatus has no effect on the lower apparatus.

The invention is naturally applicable to appliances other than railway pantographs for the solution of similar problems. For example, it may be applied to station and sub-station pantographs in power distribution networks. In such applications, the pantograph may serve as a circuit breaker in which its support is fixed, that is it has zero speed during operation. In such cases the present invention permits the upward and downward displacements or upward and downward terminal displacement at a far higher speed than is customary. Such displacements may be accomplished without fear of damaging the suspended conductor while at the same time, the duration of the breaking and closing arcs is reduced.

Another advantage is to be seen in that the operation of the usual clip which must grip a suspended conductor can be controlled by the upper support. This arrangement makes it possible for the mechanical elements controlling the clip to have smaller dimensions and consequently smaller masses.

Accordingly, the present invention while disclosed in several embodiments has been described by way of illustration rather than limitation.

What is claimed is:

1. A high speed electrical pick-up apparatus for catenary wire systems comprising:

an electrically conductive current collector for contacting the catenary system to pick-up current therefrom;

first resilient support means connected to said current collector, said first support means permitting displacement of said current collector of sufficient amplitude to allow said current collector to follow variations in height caused by the flexibility of the catenary; and

second resilient support means connected to said first support means, said second support means permitting displacements of said current collector of sufficient amplitude to allow the current collector to follow large displacements during movement of said current collector along said catenary;

one of said first and second resilient support means being astatic, and the other of said first and second resilient support means being non-astatic.

2. The electrical pick-up apparatus of claim 1 for a selected catenary system having a known droop between successive catenary supports wherein:

the first support means has a total displacement accommodation greater than the known droop of the catenary.

3. The electrical pick-up apparatus of claim 1 wherein:

said first resilient support means includes resilient pantograph means; and

said second resilient support means includes a structure composed of resilient pantograph means.

4. The electrical pick-up apparatus of claim 1 wherein:

the first resilient support means is a resilient single-leg semi-pantograph suspension.

5. The electrical pick-up apparatus of claim 1 wherein:

the second resilient support means is a structure composed of a resilient semi-pantograph of the single-leg type.

6. The electrical pickup apparatus of claim 1 wherein:

the second resilient supporting means is fluid-operated piston and cylinder assembly.

7. The electrical pick-up apparatus of claim 6 wherein:

the first resilient supporting means includes a spring biased, telescoping rod mounted coaxially in the piston and resiliently supported, in operating position, by the pressurized fluid in the cylinder.

8. The electrical pick-up apparatus of claim 6 wherein:

the piston and cylinder assembly includes an orifice means interconnecting the fluid chambers on opposite sides of the piston.

9. The electrical pick-up apparatus of claim 1 wherein:

the second support means includes a controlled actuating means for controlling the position of the second support means.

10. The electrical pick-up apparatus of claim 9 including:

control means connected to the first resilient support means and responsive to movements of the first support means for controlling the movement of the second resilient support means.

11. The electrical pick-up apparatus of claim 9 wherein:

the first support means includes limiting means to limit displacement of the first support means; and

the control means is responsive to the limiting means of the first support means for controlling the second resilient support means.

12. The electrical pick-up apparatus of claim 1 wherein:

the first and second support means have a combined stiffness no greater than 1 kilogram per centimeter.

13. The electrical pick-up apparatus of claim 1 wherein:

the second resilient support means includes damping means for attenuating selected displacement frequencies.

14. The electrical pick-up apparatus of claim 13 wherein:

the damping means has a damping coefficient no less than 0.2 kilogram-seconds per centimeter and no greater than 0.8 kilogram-seconds per centimeter.

15. The electrical pick-up apparatus of claim 1 wherein:

the first resilient support means includes a friction braking means for controlling the large, low frequency displacements of the second support means.

16. The electrical pick-up apparatus of claim 1 wherein:

said second resilient support means is astatic, and said first resilient support means is non-astatic.

17. A method of transferring electrical energy to a high speed apparatus from a stationary conductor having an irregular profile comprising:

sliding a bow along the irregular conductor, the bow being mounted to the device;

accommodating the high frequency, low amplitude displacements of the bow with respect to the high speed apparatus with a first non-astatic structure; and

accommodating the low frequency, high amplitude displacements of the bow with respect to the high speed apparatus with a second astatic structure.

18. The method of transferring electrical energy according to claim 17 including:

supporting the bow from the high speed apparatus by means of the first and second structures.

19. The method of transferring according to claim 18:

supporting the bow from the high speed apparatus by connecting the first and second structures together serially between the apparatus and the bow sliding on the conductor, the second structure being connected to the high speed apparatus.

20. The method of transferring according to claim 17 wherein the step of accommodating with the second structure includes:

damping the portion of the displacement of the bow accommodated by the second structure.

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