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No. 343,319. Patented June 8, 1886.

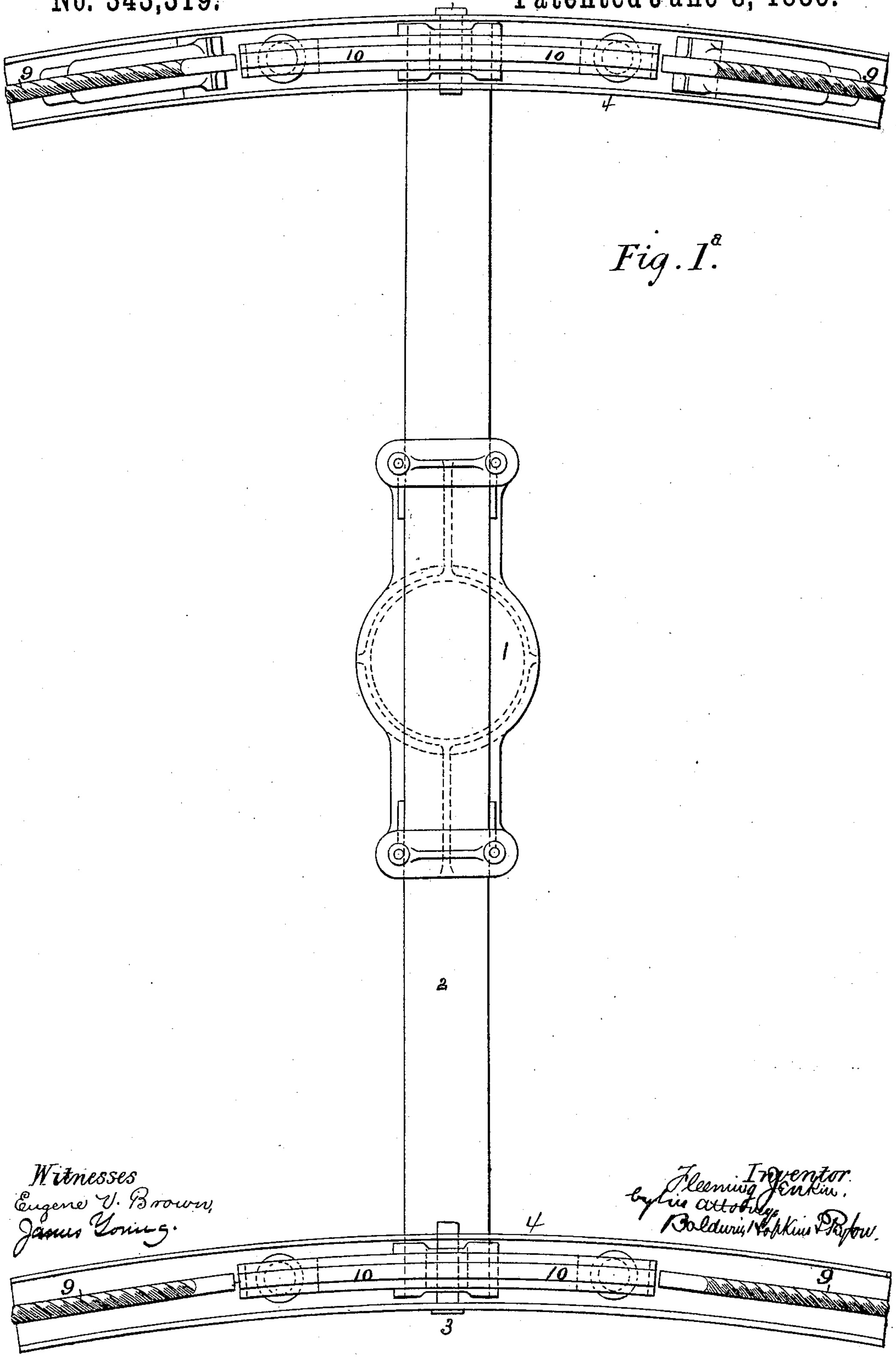

Fig. 1a.

Witnesses
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Baldwin, Hopkins & Peyton.

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Fig. 1.[b]

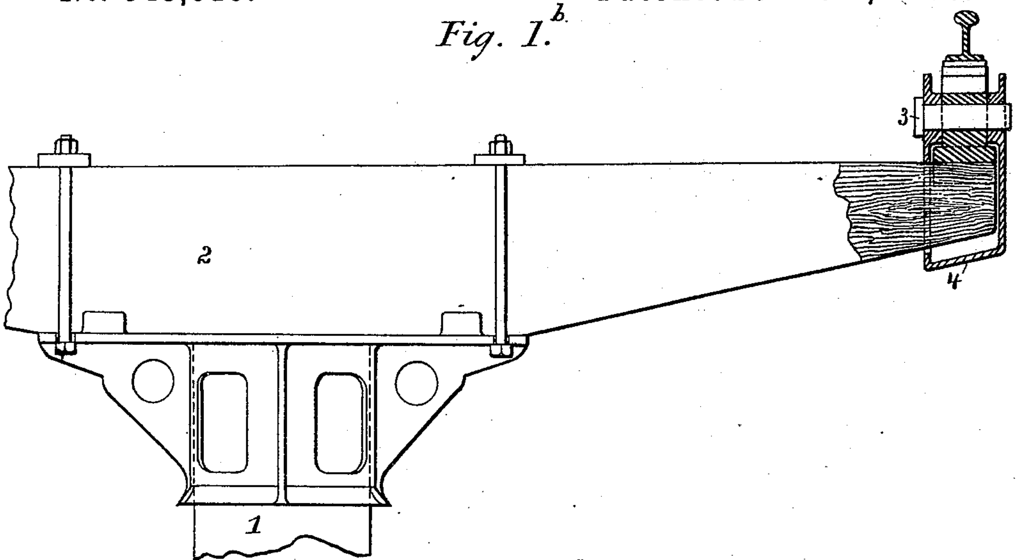

Fig. 1[c]

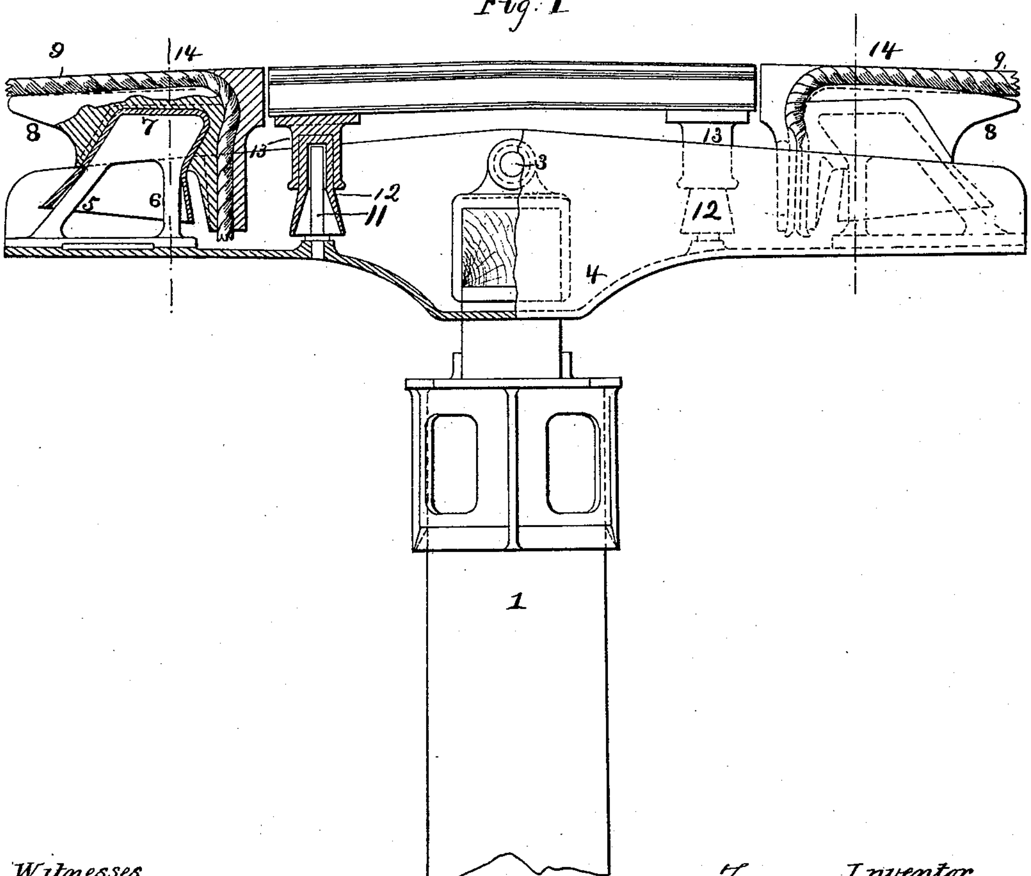

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Fig. 2.

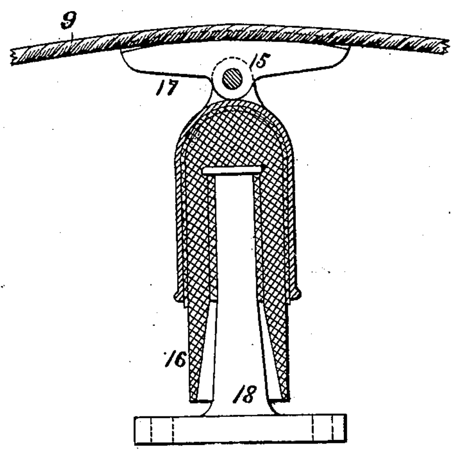
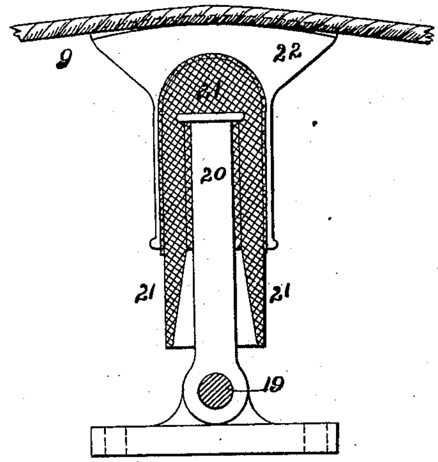


Fig. 3.



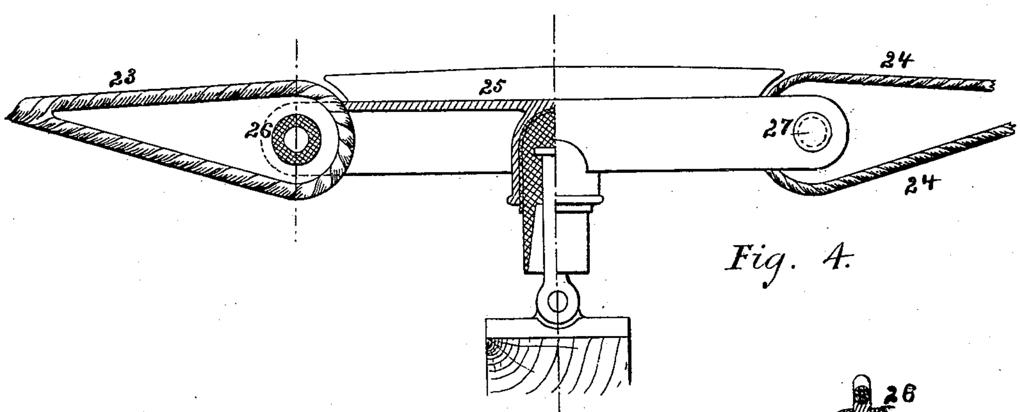


Fig. 4.

Fig. 4ª

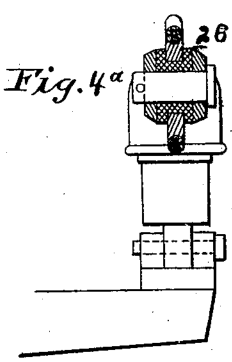


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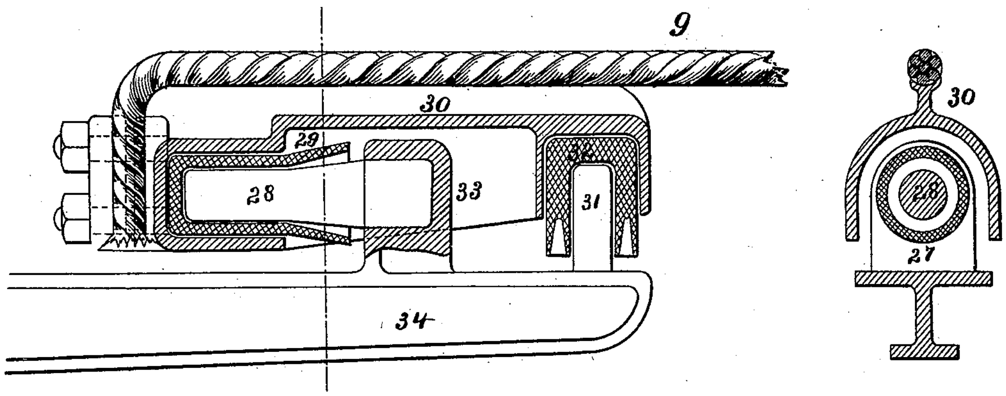
Fig. 5.



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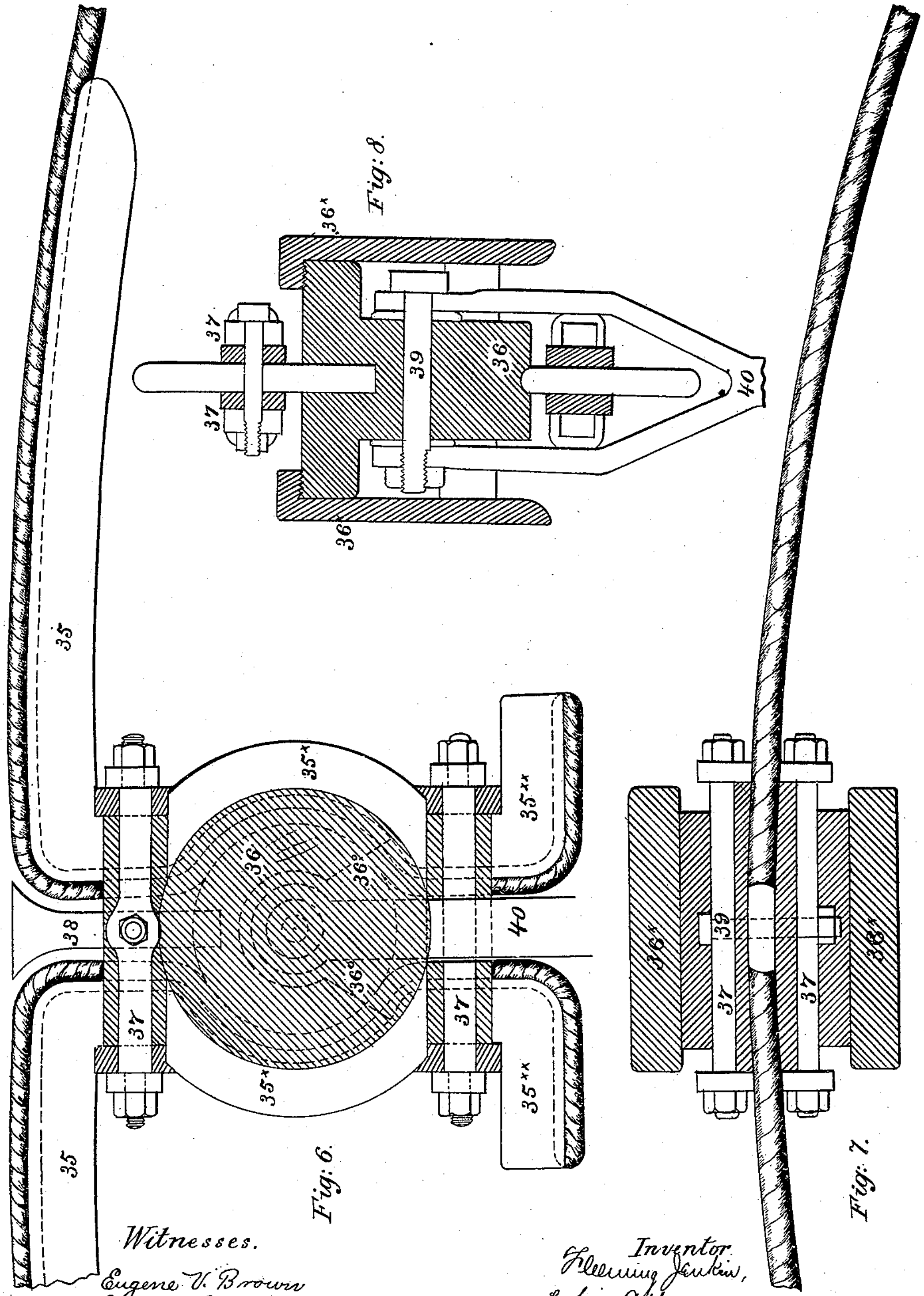

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Fig. 9.

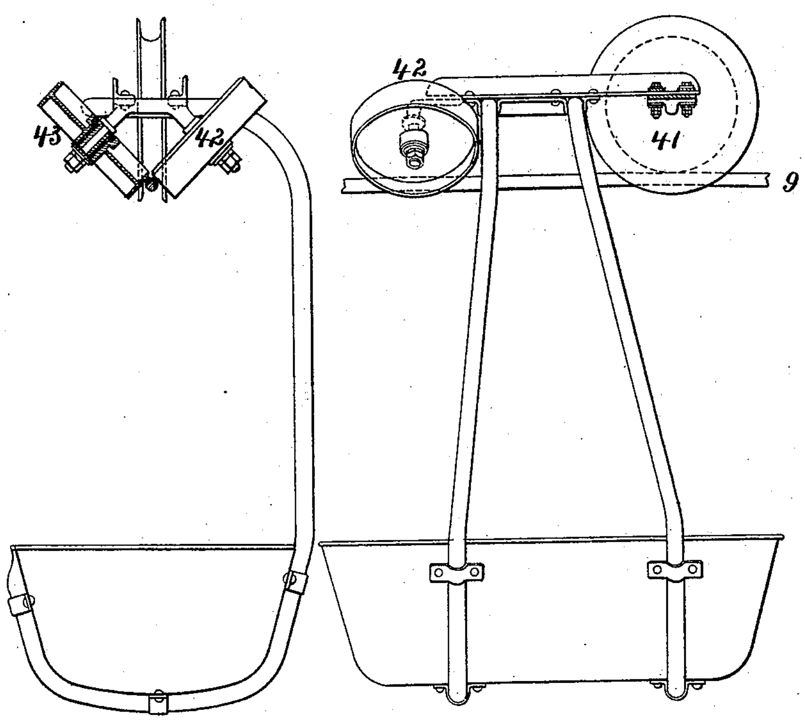

Fig. 9a.

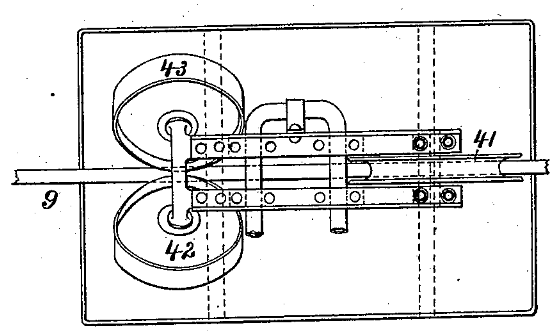

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Fig. 10.

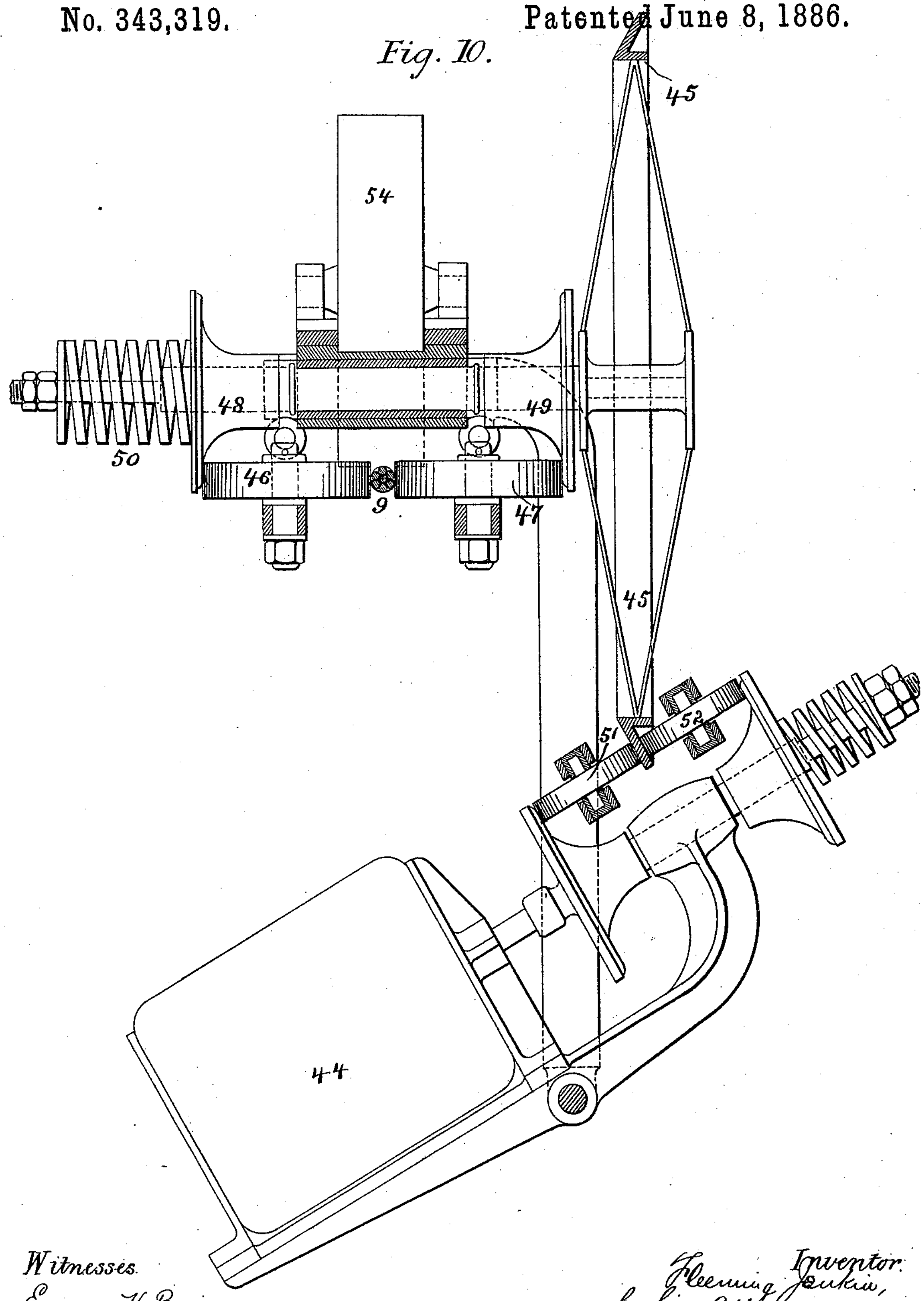

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Fig: 11.

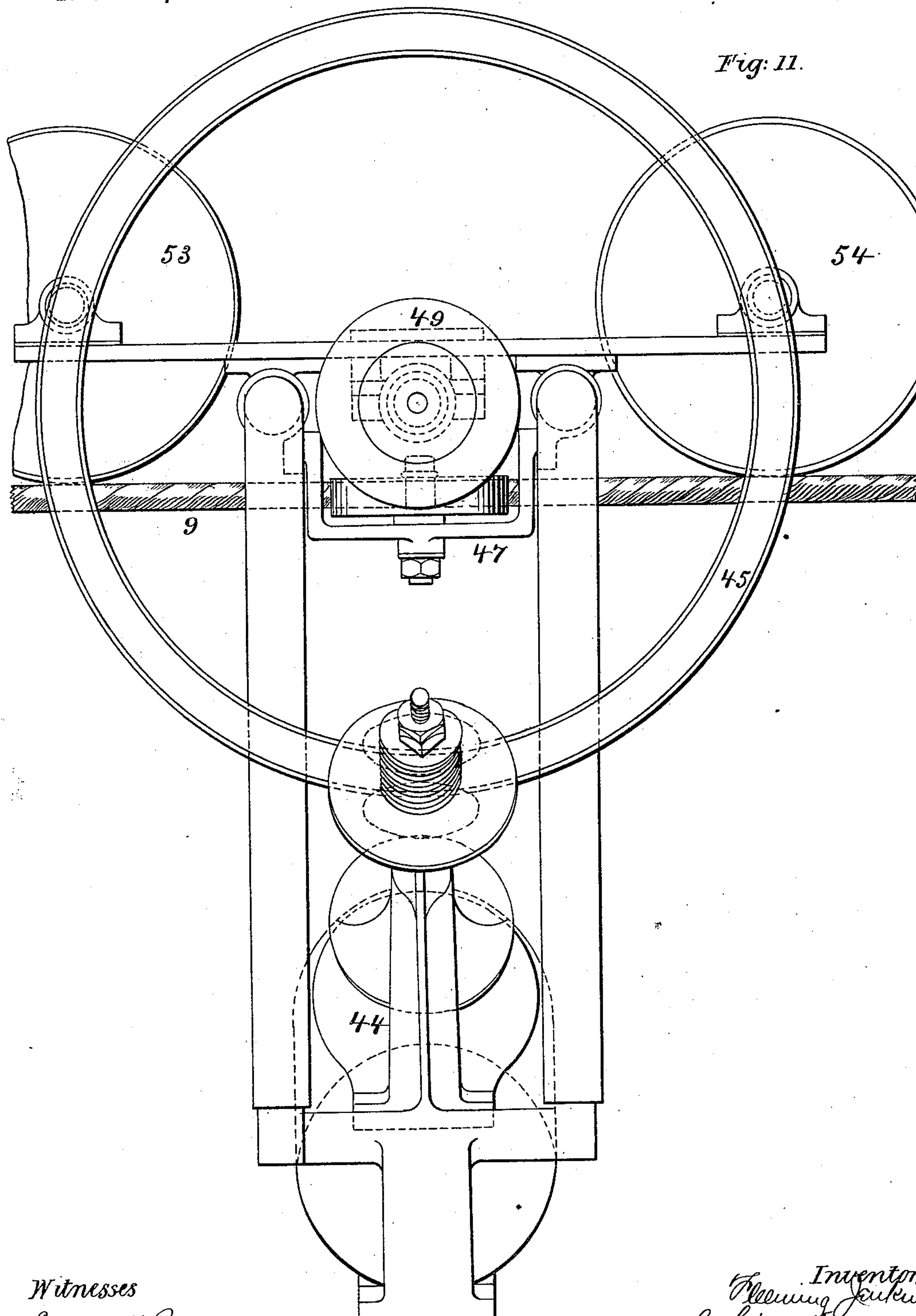

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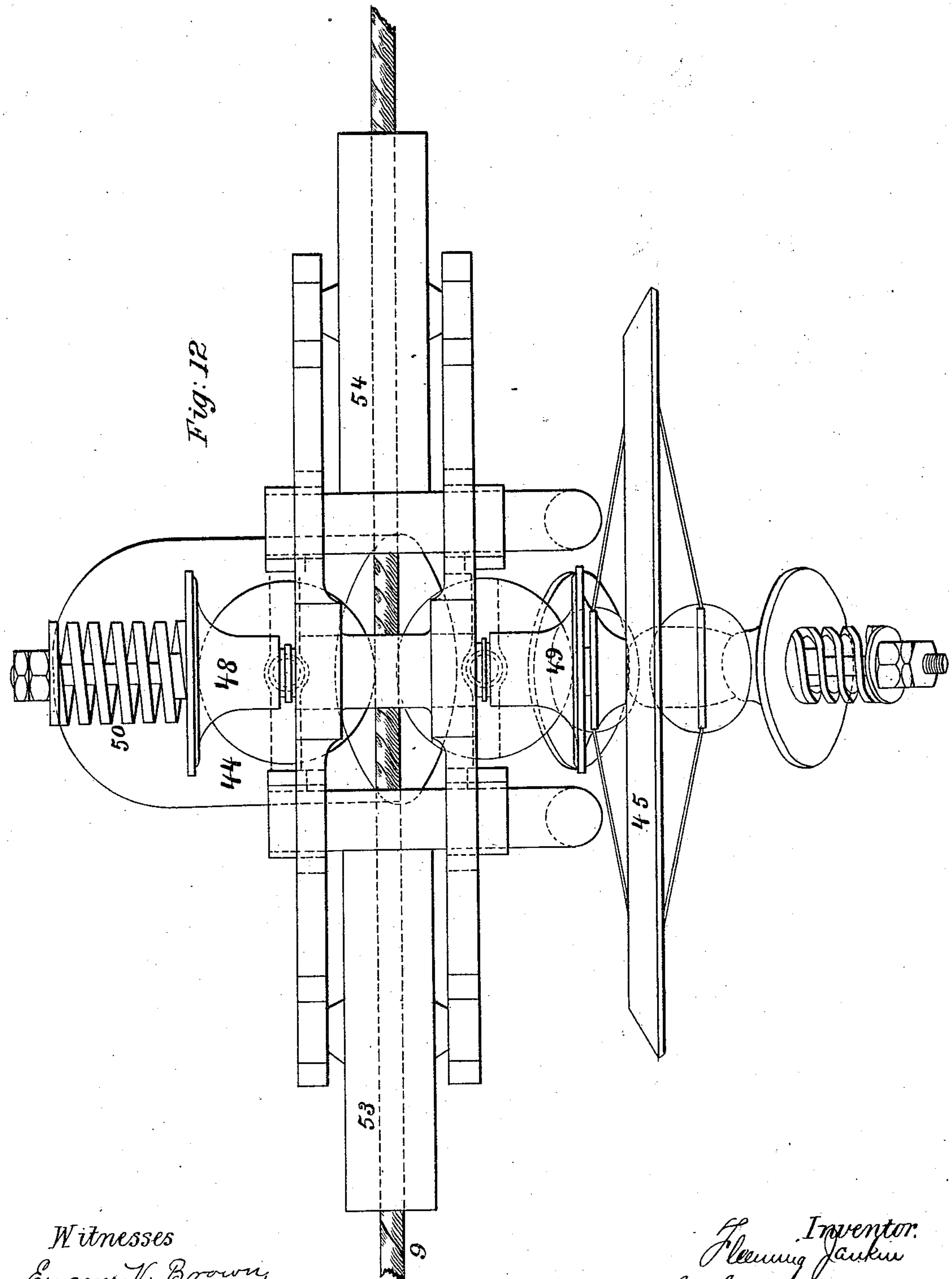
Fig: 12



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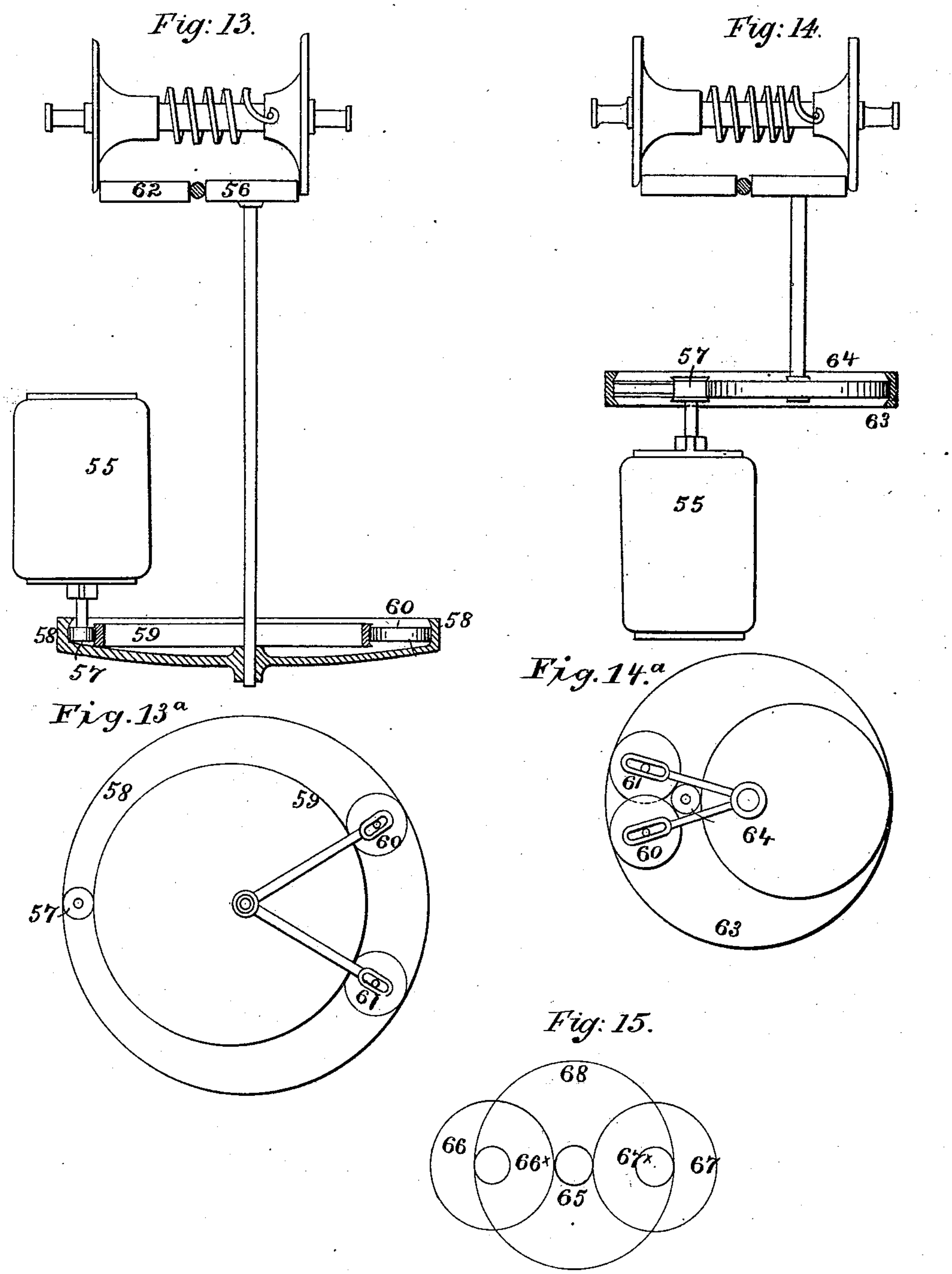

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Fig. 16.

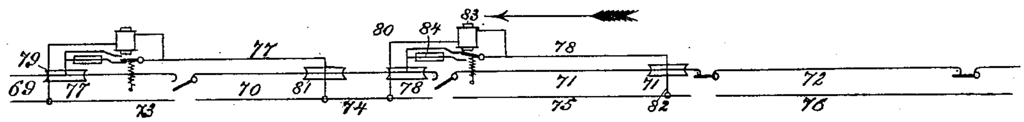


Fig. 17.

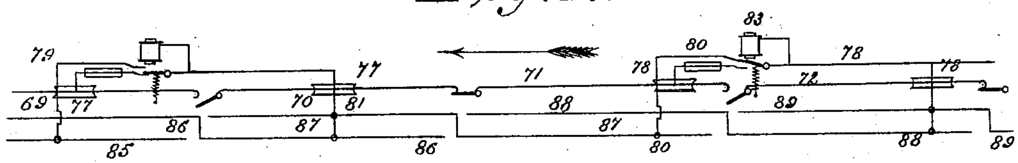


Fig. 18.

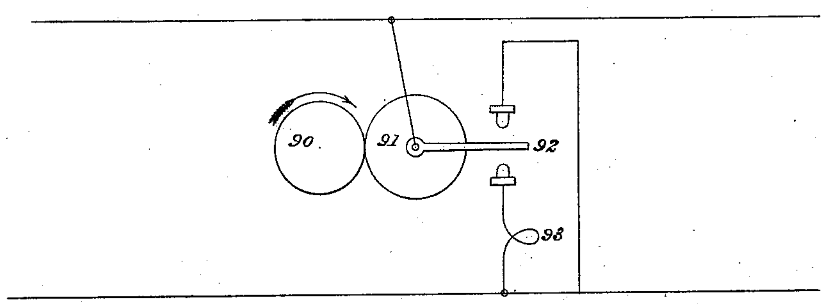
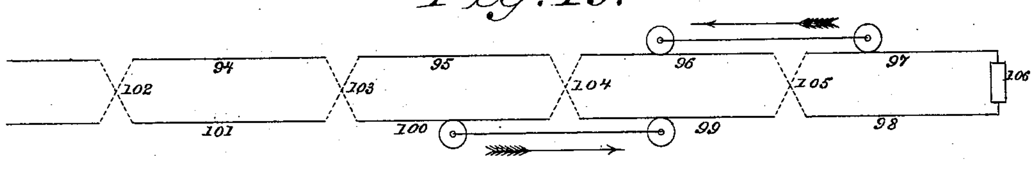


Fig. 19.



WITNESSES

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Al. C. Newman.

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(No Model.)

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Fig: 20.

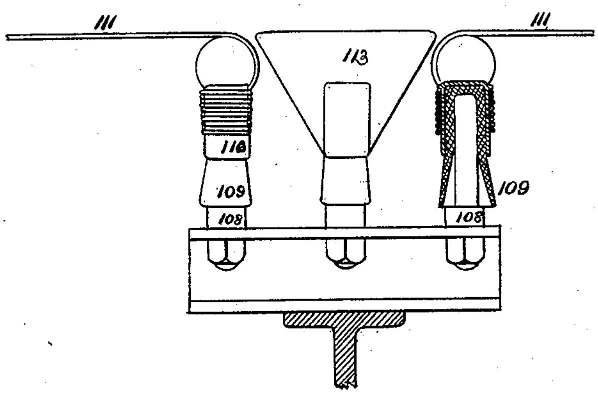

Fig: 21.

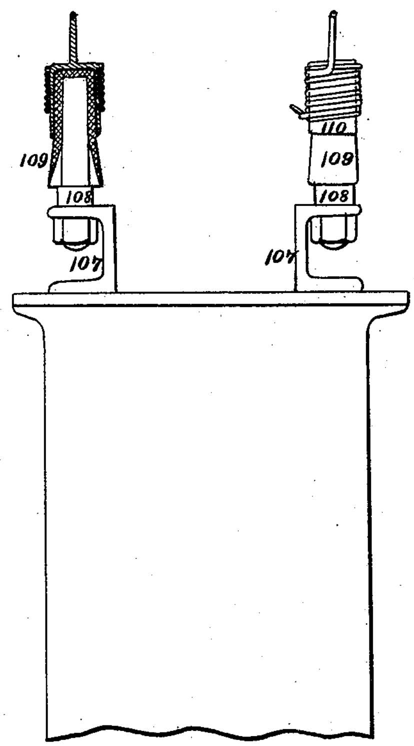

Fig: 22.

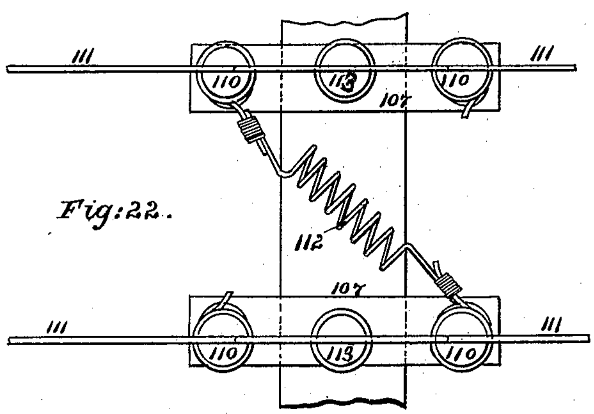

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Fig: 23.

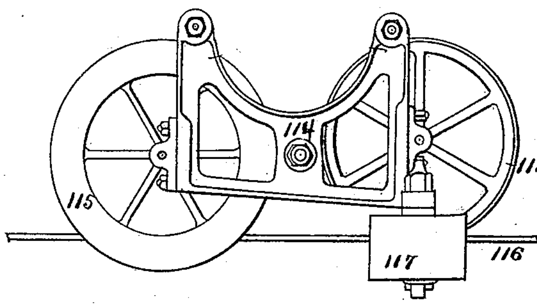


Fig: 24.

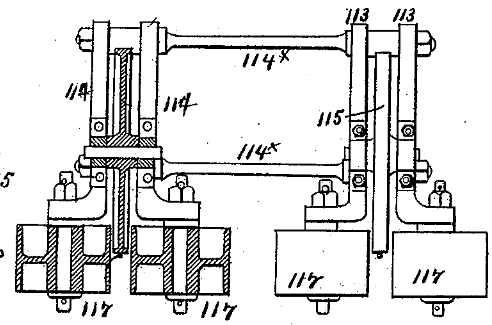
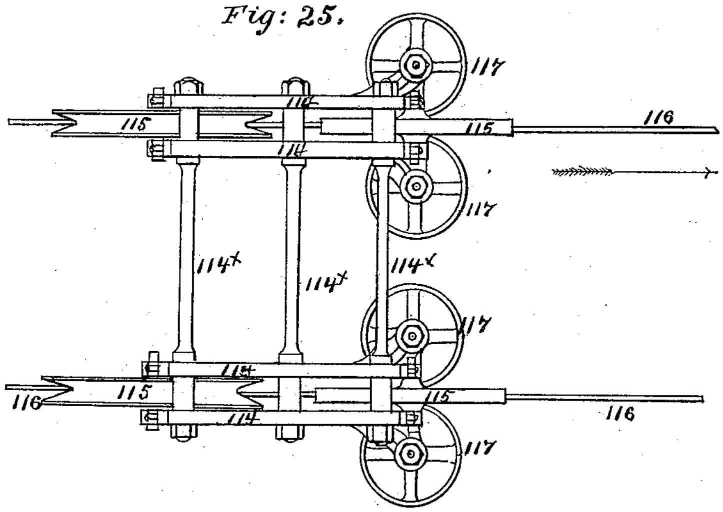


Fig: 25.



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No. 343,319. Patented June 8, 1886.

Fig: 27.

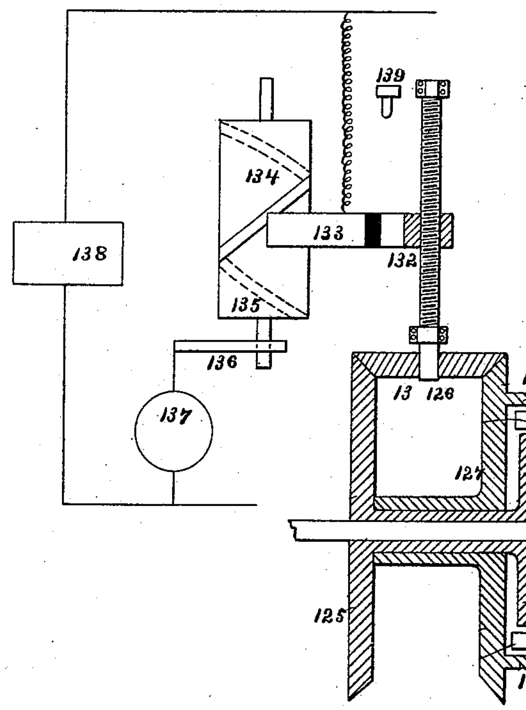
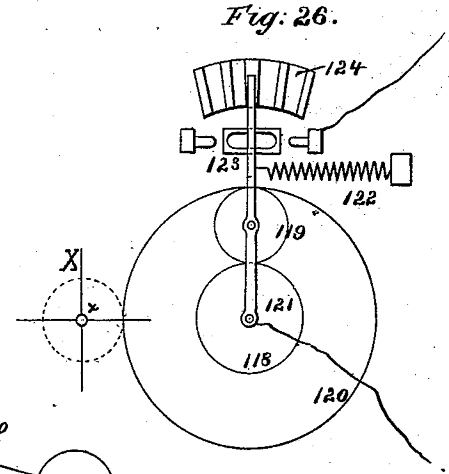


Fig: 26.



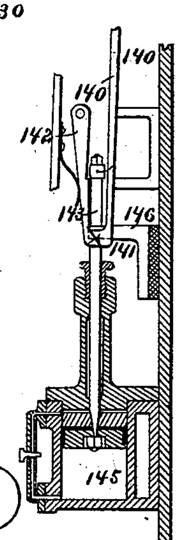


Fig: 29.

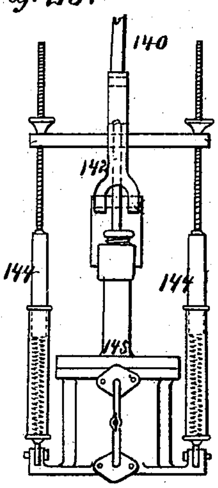
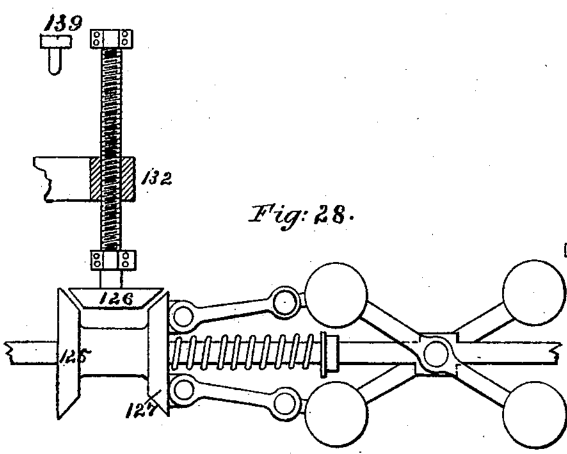


Fig: 28.



Witnesses
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N. PETERS, Photo-Lithographer, Washington, D. C.

UNITED STATES PATENT OFFICE.

FLEEMING JENKIN, OF EDINBURGH, SCOTLAND; JOSEPH I. PEYTON, OF WASHINGTON, DISTRICT OF COLUMBIA, ADMINISTRATOR OF SAID JENKIN, DECEASED.

MECHANISM FOR TRANSPORTING GOODS, &c., BY ELECTRICITY.

SPECIFICATION forming part of Letters Patent No. 343,319, dated June 8, 1886.

Application filed May 23, 1883. Serial No. 95,944. (No model.) Patented in England September 23, 1882, No. 4,548.

To all whom it may concern:

Be it known that I, FLEEMING JENKIN, a subject of the Queen of Great Britain, residing at 3 Great Stuart Street, Edinburgh, Scotland, have invented certain new and useful improvements relating to mechanism for transporting goods and passengers by the aid of electricity and the regulation of the speed of machinery driven by electricity, (for which I have received Letters Patent in Great Britain, No. 4,548, dated September 23, 1882,) of which the following is a specification.

This invention has for its primary object improvements in that system of electrical transport which I have called "telpherage," in which electrically-propelled and automatically-controlled vehicles or trains run upon an elevated rope or rail, which also serves as a conductor to convey electric energy, and all parts of the invention have been specially designed with this specific purpose; but certain parts will also be eminently useful in other electrical and mechanical combinations.

The improvements have five specific objects: First, providing good insulation consistently with strength in the telpher lines; second, providing locomotives which shall run on lines with a minimum of friction; third, securing a definite minimum interval between the trains; fourth, an improved method of applying the parallel-arc system of propulsion; fifth, the automatic governing of the electric motors.

In the accompanying drawings, Figures 1 to 8 show insulators. Fig. 9 shows a carriage. Figs. 10, 11, 12, 13, 14, and 15 show locomotives. Figs. 16 and 17 show methods of blocking. Fig. 18 shows a detail of the blocking system. Fig. 19 shows an arrangement of conducting road for working on the parallel-arc system. Figs. 20, 21, and 22 show insulator for block-wires. Figs. 23, 24, and 25 show a circuit-closer in the form of a carriage to run on the wires. Figs. 26, 27, and 28 show governors for regulating the speed of a train or of machinery driven electrically. Fig. 29 shows detail of governing apparatus.

First part. The problem of designing supports competent to take stresses of many tons and yet to maintain good insulation is one of considerable difficulty, and the first part of my invention relates to the means to be adopted for securing this end. I employ two types of insulators, which I will term the "abutment-insulator" and the "rocking insulator." The abutment-insulator is employed wherever there is discontinuity of stress in the strained rope or rod. The rocking insulator is employed when the successive spans of rope or rod are so joined that the stress from one span is continued to the next.

In Fig. 1, (comprising 1^a, 1^b, and 1^c,) 1 is a post firmly fixed in the ground. 2 is a cross-head on the top of the post. 3 3 are pins at the ends of the cross-head, which attach to it the saddle-pieces 4 4. The saddle-pieces are able to rock on the pins 3 3, to accommodate themselves to the strains. 5 and 6 are two legs of a piece which forms the rope-support. This piece is securely bolted to the saddle 4, and each saddle, as will be seen, carries a rope-support upon each of its ends. 7 is an insulating-cap, of vulcanite or earthenware, fixed onto the rope-support by means of cement. 8 is a cast-iron bonnet fixed upon the cap 7. The wire rope or bar 9, on which the vehicles run, is laid in a groove passing along the top and down the back of the bonnet, where it is clipped and securely held. The bonnets 8 also serve as horn-pieces to ease the passage of the vehicle onto and from the rope, and are suitably curved to this end where the rope bears upon them. They are also curved, as seen in plan, when a change of direction is required. 10 is a short length of rail placed in the interval between the ropes at the two ends of the saddle. It is carried by the metal stems 11 11, fixed in the saddle. 12 12 are earthenware insulators on the pins 11. On the top of the insulators metal caps 13 are secured, and to the caps the rails 10 are fixed. Each main insulator, composed of the parts 5, 6, 7, and 8, takes the whole stress of the rope. The peculiarities of the insulator are the employment of a tension member, 6, and a compression member, 5, with feet spread a considerable distance apart; the arrangement of these members so that their axis intersects at the point 14 in or near the line of the rope; the narrow insulating-cap 7, embracing those members; the metallic cover or bonnet 8, which at the same time forms the horn-piece supporting the rope, and is curved in one or in two planes as the line is straight or curved. In the drawings the two abutment-insulators are shown as fixed to a saddle rocking on the pin 3, but the abutment-insulators may be attached to a rigid support.

Fig. 2 shows one form of rocking insulator which may conveniently be employed to support the rod or rope 9 in some parts of the line where electrical continuity is desired. The rope is here shown continuous, but the same form of insulator is applicable when the two sections of the rope are more or less perfectly insulated from one another, as will be presently described. In Fig. 2 the rocking pin 15 is itself insulated by the cap 16, and the horn-piece 17, curved in one or two planes, rocks on this pin. With this insulator a small cross strain will come on the supporting-pillar 18 when the span on one side is loaded and the other span unloaded. The supporting-pillar 18 is intended to be fixed by its foot upon a post and cross-head similar to the parts 1 and 2 in Fig. 1.

Fig. 3 shows another modification which may replace the arrangement shown by Fig. 2. In Fig. 3 the rocking pin 19 is not insulated, but supports the pillar 20, which in its turn supports the insulating-cap 21. This cap supports the metallic cap 22, the horn-piece being curved in one or in two planes.

As has been already pointed out, the mechanical continuity of the rope shown in Figs. 2 and 3 does not imply electrical continuity, and in Fig. 4 the last-described insulator is shown in combination with the electrical insulation of the section 23 from the section 24. The horn-piece 25 now acts on a stretcher or connecting-link between 23 and 24, which are insulated by rings 26 and 27. The insulation of 23 from 24 is of a much lower order than the insulation of the rope as a whole, all that is required being that a sufficient resistance should be interposed between them to send the bulk of the current through the motor when the switch used in my series system breaks the metallic contact between 23 and 24. The arrangements in connection with this switch are fully described in the specification of my United States of America Patent No. 305,194, dated September 16, 1884, and need not now be repeated.

Fig. 5 shows another form of abutment-insulator. 28 is a steel pin inside an insulating-cup, 29, onto which the metal horn-plate 30 fits. This horn-plate is also supported by a metal pin, 31, inside an insulating-cup, 32. The pin 28 is fixed into the abutment 33 on the rocking piece 34. This rocking piece also carries the pin 31, and is itself supported by a post and cross-head in the manner described in respect to Fig. 1. The shearing stress is taken by the abutment 33. This abutment acts also as a tension member, with 31 as the compression member of the cantilever resisting the couple due to the strain on the rope and the resistance of the rocking piece 34. By making the pin 28 strong enough the parts 31 and 32 may be dispensed with. By an obvious inversion the pin and cap may be turned round on the piece. This is a strong, compact, and low form of abutment-insulator. When wire ropes are employed as the insulated conductor, I employ sometimes another special form of insulator capable of resisting a great strain, and also of allowing the ropes to rock on the point of support, and so relieve the supports from inconvenient strain. The ends of the wire ropes are secured in bent wrought-iron pieces clipped to a circular insulator free to rotate round a center pin.

Fig. 6 is a side elevation, Fig. 7 a plan, and Fig. 8 a vertical cross-section, through the center of the insulator.

The insulator consists of the following parts: 35 35 are horns of metal, receiving the wire rope in a shallow groove on the upper side. They are bent at $35^{\times}$ round the main insulating-piece 36, and are again bent back at $35^{\times\times}$. The rope passes between 35 and 36, and is also bent back at $35^{\times\times}$, where it can be secured by being lashed to the horns. The horns can also be bent, as shown in plan, when the post stands at an angle. The two horns are clipped together by straps 37, which are insulated from them by insulating packing-pieces. A piece of metal, 38, fixed in the main insulator, helps to bridge the gap between the ends of the wire. The main insulating-piece 36 is carried by a pin, 39, which is supported by a fork, 40. The surface of the main insulator near the pin is shielded from the wet by the outer pieces, $36^{\times}$. The form of the piece 36 itself, as shown by the lines (marked 36°,) in the side elevation, contributes to this result. The rocking action on the pin 39 prevents undue strain from coming on the support 40. The umbrella shape of insulator over the pin insures good insulation for the whole system from the earth, the resistance across the packing-pieces being sufficient for my purpose, and the mode of securing the rope is one which is not likely to cripple it. The main insulation of the system from the earth is, it will be seen, very completely provided for. The support is only connected with the conducting-rope by insulated material, which from its form is effectually sheltered from rain. The insulation of one section of conducting-rope from another is less perfect, as it is dependent on insulating material which is not sheltered from rain; but no loss results from such leakage as is likely to occur from section to section.

In Figs. 9 and 9^a a special and suitable bucket-carriage is shown. The weight is distributed between one leading-roller, 41, with flanges, and two guiding-rollers, 42 43, with inclined axes, the greater part being by preference thrown on the roller 41. In this carriage fore-and-aft swinging is prevented, the guiding is effected by an arrangement causing less friction than the ordinary V-pulley, and the risk of leaving the rails is diminished.

I do not limit myself to nor do I claim this form of carriage, but describe it as an improvement on the ordinary form.

Second part. A suitable locomotive is an essential feature in any telpher system, and the especial object aimed at in the present improvement is the diminution of friction both in the arrangements by which the rope or rail are gripped and the gearing by which the driving-wheels are connected with the motor. A suitable locomotive is shown in Figs. 10, 11, and 12. Fig. 10 is a view in vertical cross-section in a plane perpendicular to the rope. 11 is a side elevation, 12 a plan. 44 shows the motor with its center of gravity under the rope 9. This motor 44, by what I will call "right-angle nest-gearing," drives the wheel 45. This wheel, by right-angle nest-gearing, drives the pulleys 46 and 47, which grip the rope and propel the train. The gripping action is peculiar and novel, being designed to avoid all unnecessary friction. Two rollers or pulleys, 48 49, which revolve together, press against the periphery of 46 and 47, being pressed together by the spring 50. The roller 48 slides on a feather longitudinally, while the pulleys 46 and 47 are so hung that they can approach and grip the rope. The force of the spring 50 causes no pressure on any of the four axles. The action by which 44 drives 45 is similar. The axes of 51 and 52, like those of 46 and 47, are kept in a line parallel to that of the driving-axes, but are free to approach and nip the rim of 45. The inclination of 44 is not essential. If it were horizontal, the rollers 51 and 52 should have curved rims and bear at a point. The weight of the locomotive is taken by two flat rollers, 53 and 54, into a short wheel-base.

The merits of the special locomotive are, first, the frictionless nipping; second, the frictionless gearing; third, the facilities given for turning; fourth, the spring arrangement by which small variations in the width of the roads would not injure the parts; fifth, the perfect action, no matter what the swing may be; sixth, prevention of the fore-and-aft swing; seventh, the guiding which the nip gives with no flanges; eighth, the facility for the adjustment of the position of the center of gravity. Habitually 53 and 54 would be insulated.

Two other varieties of locomotives are shown diagrammatically in Figs. 13′, 13ª and Figs. 14′, 14ª. The gripping arrangements are those already described. The motor 55 is placed vertically. The motor drives the pulley 56 by a special gearing, which I call "concentric nest-gearing." The small pulley 57, fast on the motor-shaft, is pinched between a large ring, 58, fast on the shaft of 56, and a loose pulley, 59. This loose pulley is held up by 58 and a pair of pulleys, 60 and 61. These pulleys run in suitable bearings. It will be seen that if sufficient pressure is in any way caused between the peripheries of these pulleys, 57 will drive 58, and thus 56 and 62. The necessary pressure may be given in various ways. That which I prefer is to put 59 slightly eccentrically to 58 and provide means for varying the triangle made by the centers of 60, 61, and 57, so as to grip the loose pulley 59 by abutting against 58. The centers of 60 61 should be free to move in and out from the center of 58, so that the pressure on their rims shall produce no pressure on their bearings. In Fig. 14 a somewhat similar concentric nest-gearing is shown; but in this case the outer ring, 63, is the loose ring. 64, 57, 60, and 61 are supported. The second form is suited for more rapid running. It is obvious that the gearing herein described may be advantageously employed in any class of machine in place of spur and bevel wheels. The nest principle, by which pressure between the pitch surfaces does not cause pressure on the axes, may be applied with many obvious modifications. The wheels may be tightened by being coned; and Fig. 15 shows how the pitch surfaces must be arranged for a still greater multiplication. 65 is the motor driving 66 and 67. 68 is the nest-ring, which is best made double, so as to embrace 66× and 67× on both sides.

Third. As to the means for securing a definite minimum interval. In effecting the transport of goods or passengers along rails or ropes by the aid of electricity it is desirable automatically to regulate the distance between successive trains or single vehicles, and this distance may frequently be much smaller than would be allowable in the case of trains or vehicles driven by steam. Methods have been proposed in the specification of my former United States patent, hereinbefore referred to, by which the minimum distance is determined by automatic blocking; but these methods require that some form of key or electrical switch should be fixed at frequent intervals along the line. The mechanism of these electrical switches or keys is worked partly by the direct mechanical action of a passing train and partly by electrical devices. The following methods of determining a minimum space interval between trains or single vehicles require no special keys, switches, or other moving parts fixed on the line, and will be specially advantageous when the interval between trains or vehicles is to be small, inasmuch as they avoid the multiplication of delicate and complex pieces of apparatus requiring frequent inspection. I secure the desired block or minimum interval by fixing a series of detached insulated wires or other conductors alongside the main conductor. These wires or conductors I will call the "block-wires." In the simplest arrangement these wires are each of the same length as the sections into which the main conductor is divided, and they begin and end at the breaks in the main conductor. A rubber is provided at each end of the train, placing each block-wire temporarily in connection with that part of the main conductor which is alongside it. The connection at the leading end of the train will be called the "leading cross-connection." The connection at the trailing end of the train will be called the "trailing cross-connection." The trailing cross-connection is a simple wire or other conductor. The leading cross-connection includes the coil of an electro-magnet, the armature of which is held down when a current passes and is released when no current flows. I will call this electro-magnet the "block electro-magnet." The movement of the armature, when a current passes, is made to arrest the train. This may be done in various well-known ways—for instance, mechanically by allowing a break to act, or electrically, as by cutting out the electric motor on the train, as by short-circuiting this electric motor. These or any other desirable electrical or mechanical actions may be produced directly, or they may be produced indirectly by the help of a relay. So long as only one train is on a given section the block electro-magnet is inoperative; but if the leading end of a train enters on a section still occupied by the trailing end of a preceding train a derived current will flow through the trailing cross-connection of the preceding train, the block-wire, and the leading cross-connection of the following train. The electro-magnet of the following train will then act to arrest that train until the preceding train clears the block-wire, and the following train will then be driven, as before. Fig. 16 shows this method of blocking. 69 70 71 72 are sections of the main conductor, to be connected and disconnected by switches, as described in my former patent. 73 74 75 76 are the block-wires, each of the same length as the sections into which the main conductor is divided. 77 and 78 are two trains. 79 and 80 are the leading cross-connections, and 81 and 82 are the trailing cross-connections. In Fig. 16 the train 78 is blocked by the action of a derived current flowing from 71 through 80, 74, and 81. One mode in which the electro-magnet 83, which then attracts its armature, may act to cut out the motor 84 is shown diagrammatically. The armature of the magnet forms a switch, and this in its movement diverts the main current into a shunt, which enables it to flow along the train from section 71 of the line to section 70 without traversing the motor. In this simple form my invention is applicable to what I have called "telpherage"—*i. e.*, where the line is intended to convey light vehicles following each other in rapid succession. The block-wires will check any train which tends to gain on those which precede; but if by accident a train were to stop so that its trailing-wheel had only just entered upon a new section, the following train might run into it, for the second train experiences no check until it enters on the section which is occupied by the trailing-wheel of the preceding train. In order to make the block act with a minimum interval equal to that of one section of the main conductor, I prolong each block-wire behind the section it is intended to protect and make each block-wire twice the length of one section of the main conductor. The half of each block-wire at which the train first arrives I will call the "second half" of the block-wire. The other half of the wire I will call the "first half." The rubber of the leading cross-connection puts the main conductor into connection with the second half of one block-wire. The rubber of the trailing cross-connection puts the next section of the main conductor into connection with the second half of the next block-wire, and also with the first half of a third block-wire. The block electro-magnet is in the leading cross-connection. When a following train overtakes a preceding one so far as to enter on the section next to that occupied by the trailing-wheel of the preceding one, a derived current flows from the main conductor through the leading cross-connection of the second train, a block-wire, and the trailing cross-connection of the first train back to the main conductor. This current will continue to flow if the second train be forced forward into the same section of the main conductor as is occupied by the trailing-wheel of the first train, but the block-wire employed will have changed.

Fig. 17 shows the arrangement by which the block is made to act with a minimum interval equal to the length of one section of the main conductor. 69 70 71 72 are sections of the main conductor. 85 86 87 88 89 are block-wires, which are twice the length of one section of the main conductors, and are arranged by crossing, as shown in the diagram, to make the connections with the leading and trailing cross-connections 79 and 81, as described above. The train following is blocked by a derived current through 81, 87, and 80. The same device may be employed to make the minimum interval twice, three times, or n times the length of each section of the main conductor. For this purpose three, four, or $n+1$ block-wires will be required, respectively. Similar arrangements are applicable to blocking trains propelled on the parallel-arc system. The block is independent of the direction in which the preceding train has been moving; but if the preceding train has been moving back upon the following train, although it will not stop any following train, it will not itself be stopped. In telpherage this backing is never required. A backing train can be automatically prevented from running back into a following one by arranging the mechanism so that when any train runs backward a block electro-magnet is automatically inserted in what is properly the trailing cross-connection. One mode of effecting this automatic insertion would be to have two frictionally-geared wheels, as shown in Fig. 18, lightly pressed together. Wheel 90 is driven by the motion of the train, so that its motion is reversed when the train backs. The wheel 91 has a contact-piece, 92, by which the block electro-magnet 93 is cut out or put in. The friction lifts the contact-piece during forward motion, but depresses it when the train is reversed.

The parallel-arc system may be worked with arrangements similar to those which I have described in respect to the series system. The leading wheels of the train being on a section of the line which is at one electrical potential and the hinder wheels on another section, which is at another potential, while a conductor on the train itself, including the motor by which the train is propelled, forms a connection between the two. For this purpose a continuous rope or rod constitutes both the road or way and the main conductor, and this rope or rod is made to cross alternately from the up to the down and from the down to the up sides, so that when the conductor charged positively is on the up side the conductor charged negatively is on the down side, and vice versa. The up and down lines are then divided into equal-length sections, as in the series system, and the train is of the length of one section, or nearly so. The leading end of the train is, say, on a positive section and the trailing end on a negative section. Fig. 19 shows this special arrangement of conductors by which the parallel-arc system may be worked with a single rope or rail for up trains and a single rope or rail for down trains. Two continuous conductors insulated from one another and maintained at different potentials by a dynamo are divided into equal lengths, 94 95 96 97 and 98 99 100 101. Suppose that 94 95 96 97, &c., form a single road along which a train having a row of single wheels can run, and 98 99 100 101, &c., form a second similar road. The electrical cross-connections which cause 94, 100, 96, and 98 to be a continuous conductor, and 101, 95, 99, and 97 to be a continuous conductor, are shown by dotted lines. These conductors may be ropes or their equivalent supported by brackets and insulators on each side of posts placed at 102 103 104 105. At 106 is the generating dynamo-electric machine, and the circuit is closed at the farther end of the system. It is now clear that if trains similar to those already described are placed on these roads they will be driven by currents flowing through the rubbers, and motion from one section to the next, as from 97 to 96, or from 100 to 99 will result, and one rope can be used as an up line and the other as a down line. By preference I place a piece of solid insulated material to carry the weight of the wheels at the gaps, so that the wheels in passing shall not short-circuit the conductors; but the same changes may be provided against in several obvious ways, as by insulating the wheels and lifting the rubbers by a cam at the moment of passing the gaps. By this plan of driving I combine the advantage derived from the use of the single rope or rail with the advantage resulting from the absence of all switches or keys.

I will now proceed to describe details in respect to the arrangement of the block-wires and the contact-makers working with the same by which collision between the trains is automatically prevented. Fig. 20 is a side elevation. Fig. 21 is an end elevation, and Fig. 22 is a plan showing a convenient method of mounting these block-wires. 107 107 are metal supports fixed by the side of the line. It may be on posts or brackets in any convenient position. Each support 107 carries six vertical pins, 108, and on the pins insulators 109, of pottery-ware, are fixed. The heads of the insulators are cylindrical, and they receive metal caps 110. To four of these caps the block-wires 111, which are strained between the support like ordinary telegraph-wires, are securely attached. As the drawings show, the wire is led down over the curved head of the cap 110, and is twisted and securely fixed around the body. 112 is a cross-connection coupling two of the wires. The other two terminate at the support. 113 are bearers for the contact-maker or circuit-closer, hereinafter described, to lead it without concussion from wire to wire. The circuit-closer takes the form of a carriage. It is shown by the figures following: Fig. 23 is a side elevation. Fig. 24 is an end elevation, partly in section, and Fig. 25 is a plan. 114, Figs. 23 to 25, are metal frames. They are connected by the cross-bars $114^{\times}$ and are provided with metal wheels 115. The wheels 115 run on the block-wires 116, and the carriage serves electrically to connect the wires on which it stands. 117 are side rollers, to prevent the carriage running off the wires. A light rod (not shown in the drawings) forms the connection between the carriage and the train drawn by the electric motor. The carriage described so far connects together the parallel wires on which it stands, which, as already known, is what is desired in one of the connections. (See Fig. 17.) When the carriage is used on a system such as shown in Fig. 16, the wheels on one side will run on the block-wires and those on the other side on the main conductor.

I now pass to the explanation of the means which I employ for the regulation of the speed at which the train when unchecked is propelled, or more generally for the regulation of the speed of machinery driven electrically. My object is to provide means by which the speed of trains propelled as hereinbefore described, or of any machine or part of a machine driven by an electrical current, may be maintained constant or adjusted independently of variations in the resistance to be overcome, or in the source from which the electrical energy is derived, or in the circuit, or in the number of machines to be driven by that circuit. I have already described some modes of obtaining this result in my former patent; but I obtain the same result without the use of relay or electric motor in the following way: I gear three wheels, as illustrated by Fig. 26, in such a manner that the first drives the second, and if the axis of the second remains stationary the second drives the third. If, however, the motion of the third is resisted by a force exceeding a given adjustable amount, the third wheel remains at rest, and the axis of the second wheel is displaced. The arrangement is sometimes called "differential gearing." I connect the third wheel with some resistance—such as that due to a fan or centrifugal brake, a pendulum, or the flow of water through an orifice—such that this resistance increases with the speed at which the machine to be governed is running. I oppose another resistance, which may be constant, or nearly so, to the motion of the axis of the second wheel, and to this I attach the make-and-break piece or commutator or other means of controlling the electrical current supplied to the motor in such a way that so long as the axis of the second wheel remains at rest the full driving-current passes through the motor; but when with the increase of speed the resistance to the motion of the third wheel increases and the axis of the second wheel moves, this motion breaks the circuit or reverses the connection or moves the breaks or short-circuits the motor or throws in resistance. In fine, the motion of the axis of the second wheel is used to effect any desirable change in the electrical connections. When the speed has fallen so low that the resistance to the motion of the third wheel has again fallen to the normal amount, the axis of the second wheel returns to its old position, undoing the change previously made. This is effected by using a spring or weight to resist the motion of the axis of the second wheel. The axis of the second wheel moves between two fixed stops, which may be put far apart, in order to avoid continual interference with the circuit when running at nearly the normal speed. The make-and-break piece attached to the axis of the second wheel may be so arranged as only to alter the circuit when near to two ends of its travel.

Fig. 26 illustrates diagrammatically the arrangements described above. Let 118 and 120 be the pitch-lines of two wheels, both the external and internal wheels gearing into pinion 119. 118 and the 120 are concentric, but not on same shaft, or one loose on the shaft 119 is centered on the arm 121, which is pulled against a stop by a spring, 122. 118 is driven by the motor to be controlled. 120 is resisted by any resistance which increases with the speed—as by a fan, centrifugal arrangement, or water-governor. In the drawings I have shown a fan, X, on the shaft of a wheel or roller, *x*, that bears against the periphery of the wheel 120 and is driven thereby. The resistance afforded by the fan increases with the speed of the wheels 120 and *a*. At a certain speed the arm 121 will begin to rotate round the center, and will work a make-and-break piece, 123, or a commutator, 124, or any other electrical device. The make-and-break piece 123 may have a slot in it, so that the pin indicated only moves it to or fro when the arm 121 is near the end of its travel. The circuit is through 121 123 and the right-hand stop to the motor.

It is generally desirable that the change of mechanical resistance to the motion of 120 should change largely with a small change of speed at the critical point, and one simple mode of effecting this change is by making 120 drive a brake-governor, known as "Sir William Thomson's," in which a revolving weight is habitually clear of an external rim, but at a given speed overcomes the resistance of a spring so far as to come in contact with this rim, and, as it were, put on a brake by means of the friction it creates. To control the speed of trains on my system the governor is carried on the train and regulates the flow of the current to the motor, and, if necessary, also to an electric brake. In the form of governor last described the effect produced by the governor is undone when the speed of the machine falls back to the normal desired speed or a little below it, but cases arise in which this is undesirable, as some permanent change may occur in the driving-current or in the mechanical resistance to the driven electric motor—as when the gradient of a railway or telpherage line changes—and this renders a permanent readjustment of the electrical mechanism desirable. This desirable object may to a certain extent be carried out by the simple slot arrangement described above and applied to any centrifugal governor; but I cause a governor to effect this automatically with great accuracy in the following way: I arrange a train of wheels in the manner illustrated by Fig. 27 in such manner that 125 drives 126 and 126 drives 127, or, vice versa, 127 may drive 126 and 126 will then drive 125. When 126 is turned in one direction, it produces an electrical change tending to increase the speed of the motor. When 126 is turned in the reverse direction, this change is undone. I so arrange a centrifugal governor that when the speed is below a certain point an arm presses against a smooth pulley or surface connected with 125 and so drives 126 in one direction. When the speed is above a certain point, the same or another arm presses against a smooth pulley or surface connected with 127 and drives 126 in the opposite direction; but when the speed is intermediate between the two limits the arm or arms are clear of 125 and 127 and 126 is left at rest. 126 may then be employed to shunt or cut out a motor, to throw in or out electrical resistance, or to adjust brushes, or to adjust an electric field, to apply a mechanical or electrical brake, or, in fine, to produce any change, mechanical or electrical, which regulates the speed. In this manner a permanent change may be effected which will not be undone when the motor is brought back to the desired speed. The change may, if desired, be effected in the driving-dynamo, instead of in the receiving-motor, or in both. I prefer to use this governor as follows: I connect mechanically a regulating drum or disk with the machine to be controlled. This drum or disk is divided into two parts, insulated from each other. A rubber pressing against the drum or disk alternately makes one of two connections. When one is made, the motor is driven by the current, but when the other is made the current is diverted or interrupted so as not to drive the motor. The relative length of the driving and non-driving connection depends on the position of the rubber relatively to the drum, and this position is shifted in the way above described by the wheels 125, 126, and 127. One form of this governor is shown in Fig. 27. The rubbing-pieces 128 of the balanced centrifugal governor 129 bear against the smooth surfaces 130 or 131 as the speed is above or below that required. When the speed is exactly right, these rubbing-pieces run clear. In that case the wheels are all at rest. If the speed is excessive, the wheel 126 is worked by 127. If the speed is insufficient, the wheel 126 is worked by 125. The shaft of 126 has a screw, by which a nut, 132, is worked backward or forward, and is used to produce the desired change. One mode of making the desired change—namely, that which I prefer—is shown diagrammatically in the same figure. The insulated brush 133, actuated by 132, rubs on the insulated pieces of a cylinder, 134 and 135, as shown. 134 is insulated and 135 is by another rubber, 136, connected with one terminal of a motor, 137. The other terminal of the motor is joined to the generating-dynamo 138. This, in case of a train, is effected in the manner hereinbefore described, the dynamo 138 being at a station on the line. The other pole of the dynamo 138 is connected with 133. If at one end of the cylinder the piece 135 goes all round, and at the other end the piece 134 goes all round and at intermediate points, the proportions between 134 and 135 gradually vary. The time during which the current is admitted to the motor will depend on the position of the brush 133, which is determined by the governor. The connections for 134 135 could easily be varied to suit other arrangements, in which an absolute brake might not be desirable. This system of cutting off the current for a fraction of each revolution is not new, but the mode of working it so that the cut-off shall be undisturbed so long as the speed remains constant, but may be permanently varied by a temporary change of speed, so as to be different at different times, although the speed may be the same, is new. With this arrangement, if the resistance to the motion of the motor decreased tenfold below the maximum which the motion could overcome when the current was on continually, a slight increase of speed would screw 132 along until the current was cut off for about nine-tenths of each revolution. When the speed had fallen to the desired amount, in consequence of the withdrawal of the current, the brush 133 would be left in its new position and the machinery would run at the old speed, notwithstanding the great alteration in the conditions.

Another arrangement of the governor by which the desired permanent change can be made is shown in Fig. 28. A known mechanical equivalent is substituted for the three wheels 125 126 127. In this arrangement 125 and 127 form part of one piece, which is capable of small motion along the shaft under the influence of a balanced governor. When the speed is excessive, the smooth surface of 125 drives 126. When the speed is deficient, the smooth surface of 127 drives 126 in the opposite direction, and when the speed is right both smooth surfaces are clear, and 126 is at rest. In the limiting or extreme position the nut 132 might be employed to put on a mechanical or electrical brake—as by making contact with the stop 139—and this governor can in this way be employed to put a brake on a train if it continue to run too fast, even after the whole electric current has been cut off. This effect would, however, be produced instantly, or almost instantly, after the current had all been withdrawn.

In order more effectually to guard trains or vehicles from being overtaken by those which follow, I provide apparatus by aid of which a mechanical or electrical brake is set in operation to arrest a train whenever the time during which the motor of this train has been deprived of the driving-current by any of the means described exceeds a definite length. The brake is at once removed when the driving-current begins to circulate. The effect of this arrangement is that when the block or governor acts merely to control the speed no power is wasted in unnecessarily resisting the motion of the train; but if this train runs past the block for more than a definite number of seconds, so as to be in danger of overtaking the preceding train or running too fast, then the motion of the train is checked, not only by the withdrawal of motive power, but by the action of a brake. A mode of carrying out this arrangement is shown in Fig. 29. Let the piece 140 be actuated by the governor so as to move downward when the speed increases. When this motion has reached the limit at which the speed can be controlled, as already described, by cutting off the current entirely a wedge, 141, actuates a catch, 142, so as to release the cross-head 143. This cross-head is pulled downward by springs 144, and its motion is resisted by a dash-pot, 145, or other contrivance, delaying the motion for the desired time. After the lapse of this time the cross-head 143 will fall down and make contact at 146, so as to apply an electrical brake. The time between the release of the catch and the arrival of 143 at its limiting position may be, for instance, thirty seconds, yet when the speed falls the stop 141, attached to 140, will, as soon as 140 begins to move back again, break the contact at 146, and so take off the electrical brake. As 140 rises it will again set the catch 142. The contact at 146 may be employed in many obvious ways to arrest the train, and, indeed, the mere mechanical pressure of the springs 144 on a quick-running wheel, instead of 146, would in most cases be a sufficient brake. The dash-pot 145 should not resist the upward movement of 143. If a fan were employed instead of the dash-pot, it should be driven by the descent of 143 and not by its ascent. If the part 132 of Fig. 28 be connected with and moved by the part 140 of Fig. 29, then the action will be that the current will be cut off from the motor by the apparatus, Fig. 28, and then, after an interval, if the speed does not decrease, the brake will be applied by the apparatus, Fig. 29.

Having thus described the nature of my said invention and the manner of performing the same, I would have it understood that I claim—

1. The combination of a conductor and an abutment-insulator consisting of the combination of two distinct members, one of which serves to sustain the insulator against the tension or strain of the conductor, and the other to strengthen or support the insulator against compression.

2. The combination, in an abutment-insulator, of a metal support having tension and compression members, a metal cap for the attachment of the conducting rope or rod, and insulating material interposed between such support and cap, substantially as described.

3. The combination of a conducting-rope, metal cap and insulating-cup, and a rocking support, substantially as described.

4. The combination, substantially as set forth, of a conductor and the insulator consisting of the combination of the stem or support, the metal cap having horn-pieces, to which the conductor is attached, and the insulating material interposed between the cap and its support.

5. The combination, in an insulator carrying an insulated rope or rod upon which vehicles can run, of an insulating-block capable of rocking about a pin or axis connecting it with a support, such block having horn-pieces clamped around it, and conducting ropes or rods carried on the horn-pieces, substantially as described.

6. The combination, substantially as set forth, of the laterally-curved horn-piece and the insulator on which it is mounted.

7. In an electric locomotive, rollers nipped together and driven by disks or pulleys upon a rotating axis, and embracing between them a continuous rope or rod, along which the locomotive is thus caused to travel, substantially as described.

8. The combination, substantially as set forth, of the locomotive, the driving-roller on its main shaft or axle, the motor, and the pair of rollers, driven by the motor, that nip the rim of the driving-roller between them.

9. The combination for arresting the progress of a following train, consisting of block-wires divided into sections, instruments on the train making contact with these wires and closing a circuit through them when two trains reach the same section, and an electric-circuit changer diverting the propelling-current from the motor of the following train when a current passes by the block-wire, substantially as described.

10. The combination of a train propelled by an electric current, of leading and trailing connectors on the train making contact with a block-wire divided into sections, and devices on the train which throw its motor out of circuit when the current is received by the leading connector, the block-wire, and the trailing-connector of the preceding train, substantially as described.

11. The combination of a train propelled by an electric current, block-wires divided into sections, instruments carried with the train and making contact with the said wires, and devices on the train diverting the propelling-current from the motor of the following train when two trains are electrically connected by a section of the block-wire, substantially as described.

12. The combination of a train propelled by an electric current, block-wires divided into sections, instruments carried with the train and making contact with the said wires and devices on the train, which, when two trains are electrically connected by a section of the block-wire and the leading train is backing toward the following train, divert the propelling-current from the motor of the leading train, substantially as described.

13. In a parallel-arc-railway system, the direct and return limbs of the circuit divided into sections approximately equal in length to the length of the train used, and having cross-connections between the forward end of one section and the opposite end of the next section, in combination with the train and its propelling electric motor, whereby the opposite ends of the train and terminals of the motor are maintained on sections of opposite polarity.

14. The combination, in an electric motor-governor, of a centrifugal apparatus driven by the motor, smooth rotating surfaces actuated thereby, a smooth wheel or wheels which are turned in one direction or the other by the smooth rotating surfaces actuated by the governor, and a contact-maker which is moved by said wheel or wheels, substantially as described.

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