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ELECTRICAL CHANGE SPEED GEAR

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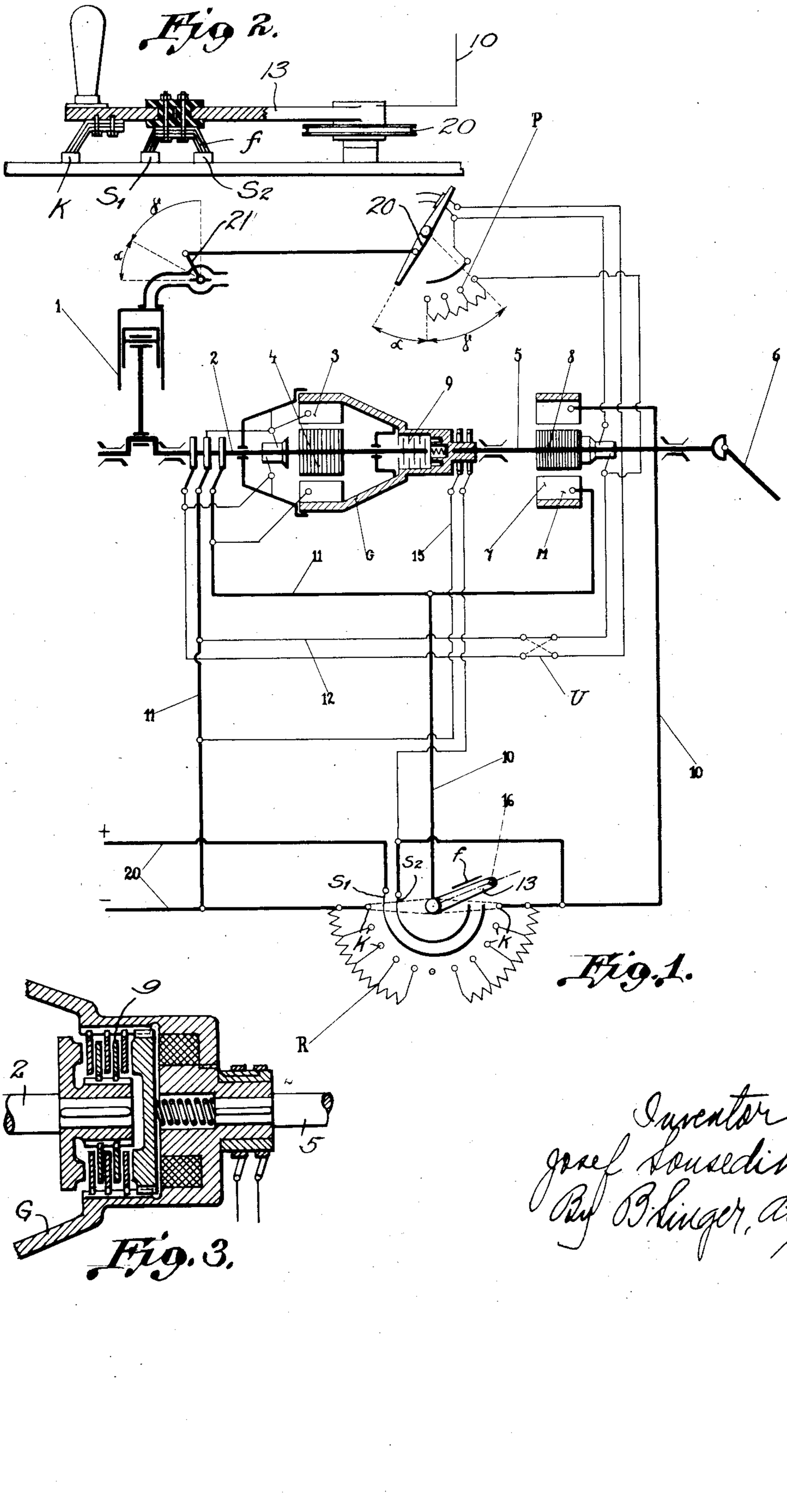

Fig. 1.

Fig. 3.

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ELECTRICAL CHANGE SPEED GEAR

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The present invention relates to electrical transmission, especially for traction machines or vehicles driven by internal combustion engines, its object being to provide electrical transmission which not only ensures a continuous regulation of the speed of revolution from zero to maximum, but also ensures at the same time an increase of the starting torque at the instant when starting.

It is known that the torque in traction machines must be greatest at starting when the motor has to accelerate the masses up to the ultimate speed besides overcoming the normal frictional resistance. For this reason the internal combustion engine has to be built for the above maximum starting torque in spite of the fact that this is only fully used at starting and the engine runs uneconomically under normal conditions. The hitherto employed regulation of the speed, for example, by gear drives or the like, is very imperfect, and the hitherto known electrical transmissions in which, for example, the internal combustion engine was employed to drive a dynamo supplying the driving motor, showed a very bad efficiency curve in that the transmission itself required much energy since it was in action during the whole time the track machine was being driven.

All these disadvantages are removed in the arrangement according to the invention in which the internal combustion engine, or other prime mover, is only dimensioned to overcome the normal resistance torque, i. e. the friction loss and the like during uniform motion of the traction machine or vehicle, while at starting the constant load of the internal combustion engine is so changed by the electrical transmission in accordance with the invention that an increased starting torque comes into being which decreases as the speed of the traction machine increases. When starting has been accomplished, the electrical transmission in accordance with the invention is put entirely out of action and the driving shaft of the traction machine is directly coupled with the engine.

An embodiment of the electrical transmission in accordance with the invention is shown diagrammatically in the drawing, by way of example.

Figure 1 shows the transmission and its associated control devices in a position in which a direct drive is established between the driving shaft and the driven shaft.

Figure 2 shows in detail in elevation and partly in section the operating lever of the special control switch.

Figure 3 shows in section an electro-magnetically controlled coupling in its energized condition in which the coupling is released.

The internal combustion engine 1 drives the shaft 2 on which is the rotor 4 of the dynamo machine G whose field structure 3 is rigidly coupled with a second shaft 5 which serves actually to drive the traction machine, for example, through Cardan transmission 6. On the shaft 5 is the rotor 8 of a second electrical machine M whose stator 7 is fixed under all conditions. The shaft 5 is independent of the shaft 2 and is only connected with the same by an electro-magnetic coupling 9 under certain conditions in the manner described later.

The excitation of the machines G and M is accomplished by means of a separate current source, for example, a battery of accumulators, and is controlled through a special switch R by means of the lever 13. This source also serves to supply the electro-magnets of the coupling 9. The exciting circuit of the machines G and M is indicated in the drawing by heavy lines, while the weak lines denote the exciting circuit of the electro-magnets and the conductors for the slip current.

The special switch R is provided with variable resistances adapted to be inserted into the excitation circuits of the electrical machines G and M respectively by the lever 13 which is connected with the conductor 10 of the exciting circuit as will be presently described. The lever 13 is conductive and is rotatably mounted to engage successively the individual contacts K of the resistances. Upon this lever 13 is mounted, electrically insulated therefrom, a contact brush *f* which remains in sliding engagement with two concentrically arranged metal strips S_1 and S_2 as long as the lever 13 is moved along the semi-circular row of contacts K. Only when the lever 13 is moved into engagement with a dead contact 16 at the extreme right hand side, the brush *f* is disconnected from said metal strips S_1 and S_2 and opens thereby the circuit 15 of the electromagnetic coupling 9.

In the extreme left position of the lever 13 indicated in dotted lines, the coupling 9 is energized from the source of current so that the cardan shaft 5 which in the de-energized condition of the coupling is rigidly connected to the armature 3 of the machine G is uncoupled from the shaft 2 driven by the engine 1. The coupling remains open until the corresponding feeding circuit 15 is interrupted, and this only occurs

when the lever 13 is moved to the extreme right contact 16.

In the dotted, extreme left position of the lever 13 the exciting current is led from the supply circuit 20 through the conductor 10 only to the stator 7 of the motor M so that the dynamo machine G is not supplied with exciting current, and therefore, neither electrically nor mechanically, is there a torque or a load transmitted from the motor 1 which rotates the rotor 4 of the machine G at normal speed. By adjusting the lever 13 to the succeeding contact K of the switch, or by switching in a certain resistance into the current return conductor, a part of the exciting current is led through the circuit 11 over the slip rings into the field winding of the field structure 3 of the machine G. However, even in this position the machine M is still strongly excited, while the machine G, on the other hand, is not fully excited, and consequently, in the latter, the mechanical energy delivered from the motor 1 is converted into an electrical current of greater intensity but lower voltage. This current is then led through the circuit 12 to the rotor 8 of the machine M by means of which the slip current is again converted into mechanical energy transmitted by the Cardan shaft 5. As the machine M is over-excited, there occurs in these circumstances a considerable torque which is so great that the traction machine is set in motion.

By further adjusting the lever 13 to the right, the excitation of the machine M is lowered and that of the machine G increased so that the intensity of the current induced in the machine G decreases and its voltage rises, and consequently, with increasing speed, the torque decreases. With the arrangement according to this invention the maximum torsion moment on the traction shaft of the vehicle at the start is attained when this maximum moment is most needed. After the acceleration of the vehicle, i. e. when the starting has been accomplished, this initial moment on the traction shaft decreases to the normal torsion moment of the internal combustion engine and in this case the revolutions of the latter are approximately the same as those of the traction shaft, so that it is then possible to have a direct connection of the driving shaft 2 with the driven shaft 5. By an electrical transmission it is therefore possible to carry out the aforementioned regulation of the revolutions from the minimum to the maximum revolutions, that are equal to the revolutions of the internal combustion engine. Because of the fact that at the start both of the machines G and M are in action and develop an increased torque on the traction shaft, these machines can be dimensioned for smaller mechanical powers than would correspond to the required increased moment at the start of the vehicle. Through the co-operation of the rotor and the field structure of the machine G, a part of the energy of the motor 1 is transmitted by the reaction of the torsion moment of the dynamo machine G to the shaft 5 so that the total load is transmitted through both machines G and M at the same time to the shaft 5. By adjusting the lever 13 from the extreme right position to the extreme left position there is attained a gradual decrease in the velocity of the traction shaft 5 down to zero by changing the excitation of both the machines G and M, analogically as was described above during the opposite movement of the lever 13. The lever 20 may be moved to its various positions either by hand or by the motion of the driver's foot. The lever 13 may also be manually moved from position to position. The torques of both machines G and M are always added together, and the resultant torque is transmitted by the Cardan transmission. Thus the velocity of the shaft 5 is half of the maximum velocity.

During the anti-clockwise rotation of the lever 13 towards the right, the excitation of the machine M decreases and that of the machine G increases. Thus the machine M is not fully excited, while the machine G is over excited and the velocity of the shaft 5 increases and the load of the motor 1 becomes transmitted to the latter more through the torque reaction of the dynamo machine G. The torque on the shaft decreases, and when the lever is in the right hand position indicated in dotted lines, in Fig. 1 then the whole load is transmitted by the strongly over-excited machine G, while the machine M, which is nearly completely unexcited, transmits almost no load. Thus the velocity of the Cardan shaft attains the maximum value, which is almost equal to the velocity of the shaft 2. Thereupon regulation and starting are ended, and the shaft 5 can be directly coupled with the shaft 2. This is attained by adjusting the lever 13 to the extreme right hand contact 16, as shown in full lines in Figs. 1 and 4 which results in interrupting the current supply to the electro-magnets of the coupling 9. At the same time the exciting current supply to the machines G and M is thereby switched off.

During normal running of the traction machine the whole auxiliary-regulating-set requires no energy, the whole load being directly transmitted from the internal combustion engine to the traction machine. It is apparent that the maximum torque of the arrangement in accordance with the invention at rest will be attained on clutching in, and that it will decrease during starting until the moment that the internal combustion engine has been fully started. The velocity increases proportionally, and can be regulated to any limit. Further, the load during starting is continuously delivered by both machines G and M so that neither of them requires to be built for the full load.

The lever 20 which, for example, may be operated by a foot pedal, serves, on the one hand, to regulate the supply of gas to the internal combustion engine by means of the regulating valve 21 during the normal speed within the limits of the angle α, and on the other hand for breaking the motor within the limits of the angle γ within which not only is the throttle valve 21 closed, but resistance is also switched into the rotor circuit of the motor M so that an effective braking is attained. In braking the machine, the operator releases the foot pedal to close the throttle thus moving the lever 20 through the angle α. He also moves lever 13 from the extreme right position in Figure 1 to the extreme left position shown in dotted lines in Figure 1. Movement of the lever 13 to its left dotted line position in Figure 1 causes a de-clutching of the shafts 5 and 2 and restores the machines G and M to their initial conditions with the field 3 de-energized and the field M energized. Further movement of the lever 20 through the arc γ (Figure 1) short circuits the armature 8 through suitable resistances thereby effecting the application of a braking force to the shaft. Besides, in the rotor circuit 12 there is a reversing switch U which serves for reversing the circuit 12 and in this way causes a reverse movement of the traction machine.

It is apparent that the described arrangement is suitable not only for the driving of traction machines, for example railway locomotives or the like, but can also be applied where it is a question of an economical regulation of the revolutions of a driving machine of any description.

The electro magnetic coupling 8 can be of any desired construction.

I claim:—

1. In a traction vehicle, a prime mover, a transmission shaft, electrical coupling means and mechanical coupling means for connecting the prime mover and said transmission shaft, said electrical coupling means comprising an electrical machine having a rotor connected to said prime mover and a field structure connected to said transmission shaft, a second electrical machine having a stator and a rotor, the latter being connected to said transmission shaft, an electrical circuit including a source of current and adapted to energize the field structure of said first electrical machine and the stator of said second electrical machine, a variable resistance in said circuit for differentially varying from zero to an over-exciting value the currents passing through said field structure and said stator respectively to transfer the load progressively from one machine to the other, and a second electrical circuit including the rotor circuits for the slip-current of said machines, said mechanical coupling comprising a clutch element on the prime mover, a clutch element on the transmission shaft, and electromagnetic means adapted to effect an engagement of said clutch elements.

2. In a traction vehicle, a prime mover, a transmission shaft, electrical coupling means and mechanical coupling means for connecting the prime mover and said transmission shaft, said electrical coupling means comprising an electrical machine having a rotor connected to said prime mover and a field structure connected to said transmission shaft, a second electrical machine having a stator and a rotor, the latter being connected to said transmission shaft, an electrical circuit including a source of current and adapted to energize the field structure of said first electrical machine and the stator of said second electrical machine, a variable resistance provided with a movable contact member in said circuit for differentially varying from zero to an over exciting value the currents passing through said field structure and said stator respectively to transfer the load progressively from one machine to the other, a second electrical circuit including the rotor circuits for the slip current of said machines, an auxiliary resistance, and auxiliary switch means for inserting said auxiliary resistance into the circuit of the rotor connected to said transmission shaft to provide a braking effect, said mechanical coupling means comprising a clutch element on the prime mover, a clutch element on the transmission shaft, and electromagnetic means controlled by said movable contact member and adapted to permit an engagement of said clutch elements when said movable contact member interrupts the excitation of said electromagnetic means.

4. In a traction vehicle, a prime mover, a transmission shaft, electrical coupling means and mechanical coupling means for connecting the prime mover and said transmission shaft, said electrical coupling means comprising an electrical machine having a rotor connected to said prime mover and a field structure connected to said transmission shaft, a second electrical machine having a stator and a rotor, the latter being connected to said transmission shaft, an electrical circuit including a source of current and adapted to energize the field structure of said first electrical machine and the stator of said second electrical machine, a variable resistance in said circuit for differentially varying from zero to an over-exciting value the currents passing through said field structure and said stator respectively to transfer the load progressively from one machine to the other, and a second circuit including the rotor circuits for the slip-current of said machines, said mechanical coupling comprising a clutch element on the prime mover, a clutch element on the transmission shaft, means normally urging said clutch elements into engagement, and electromagnetic means for disengaging said clutch elements when said field structure and said stator are excited.

5. In a traction vehicle, the combination of a prime mover comprising an internal combustion engine having a throttle valve, a transmission shaft, electrical coupling means and mechanical coupling means for connecting the prime mover and said transmission shaft, said electrical coupling means comprising an electrical machine having a rotor connected to said prime mover and a field structure connected to said transmission shaft, a second electrical machine having a stator and a rotor, the latter connected to said transmission shaft, an electrical circuit including a source of current and adapted to energize the field structure of the said mentioned electrical machine and the stator of said second electrical machine, a variable resistance provided with a movable contact member in said circuit for differentially varying from zero to an over exciting value the currents passing through said field structure and said stator respectively to transfer the load progressively from one machine to the other, a second circuit including the rotor circuits for the slip current of said machines, an auxiliary resistance, auxiliary switch means for inserting said auxiliary resistance into the circuit of the rotor connected to said transmission shaft to provide a braking effect, means for connecting

3. In a traction vehicle, a prime mover, a transmission shaft, electrical coupling means and mechanical coupling means for connecting the prime mover and said transmission shaft, said electrical coupling means comprising an electrical machine having a rotor connected to said prime mover and a field structure connected to said transmission shaft, a second electrical machine having a stator and a rotor, the latter being connected to said transmission shaft, an electrical circuit including a source of current and adapted to energize the field structure of said first mentioned electri-

said auxiliary switch means to said throttle valve for closing the latter when said auxiliary resistance is inserted into said rotor circuit, said mechanical coupling means comprising a clutch element on the prime mover, a clutch element on the transmission shaft and means for engaging and disengaging said clutch members.

6. In a traction vehicle, a prime mover, a transmission shaft, electrical coupling means and mechanical coupling means for connecting the prime mover and said transmission shaft, said electrical coupling means comprising an electrical machine having a rotor connected to said prime mover and a field structure connected to said transmission shaft, a second electrical machine having a stator and a rotor, the latter being connected to said transmission shaft, an electrical circuit including a source of current and adapted to energize the field structure of said first electrical machine and the stator of said second electrical machine, a variable resistance in said circuit for differentially varying from zero to an over-exciting value the currents passing through said field structure and said stator respectively to transfer the load progressively from one machine to the other, a second electrical circuit including the rotor circuits for the slip-current of said machines, said mechanical coupling comprising a clutch element on the prime mover, a clutch element on the transmission shaft, spring means normally urging said clutch elements into engagement, and electromagnetic means for disengaging said clutch elements when said field structure and said stator are excited, a circuit for said electromagnetic means said last named circuit being controlled by said movable contact member and being opened by said movable contact member when the same is moved to a position where it interrupts the excitation of said field structure and said stator, such de-energizing of the electromagnetic means permitting said spring means to engage said clutch elements.

7. In a traction vehicle, a prime mover, a transmission shaft, electrical coupling means and mechanical coupling means for connecting the prime mover and said transmission shaft, said electrical coupling means comprising an electrical machine having a rotor connected to said prime mover and a field structure connected to said transmission shaft, a second electrical machine having a stator and a rotor, the latter being connected to said transmission shaft, an electrical circuit including a source of current and adapted to energize the field structure of said first mentioned electrical machine and the stator of said second electrical machine, a variable resistance provided with a movable contact member in said circuit for differentially varying from zero to an over exciting value the currents passing through said field structure and said stator respectively to transfer the load progressively from one machine to the other, a second electrical circuit including the rotor circuits for the slip current of said machines, said mechanical coupling means comprising a clutch element on the prime mover, a clutch element on the transmission shaft, and electromagnetic means controlled by said movable contact member and adapted to permit an engagement of said clutch elements when said movable contact member interrupts the excitation of said electromagnetic means.

8. In a traction vehicle, the combination of a prime mover comprising an internal combustion engine having a throttle valve, a transmission shaft, electrical coupling means and mechanical coupling for connecting the prime mover and said transmission shaft, said electrical coupling means comprising an electrical machine having a rotor connected to said prime mover and a field structure connected to said transmission shaft, a second electrical machine having a stator and a rotor, the latter being connected to said transmission shaft, an electrical circuit including a source of current and adapted to energize the field structure of the said mentioned electrical machine and the stator of said second electrical machine, a variable resistance provided with a movable contact member in said circuit for differentially varying from zero to an over exciting value the currents passing through said field structure and said stator respectively to transfer the load progressively from one machine to the other, a second circuit including the rotor circuits for the slip current of said machine, an auxiliary resistance, auxiliary switch means for inserting said auxiliary resistance into the circuit of the rotor connected to said transmission shaft to provide a braking effect, means for connecting said auxiliary switch means to said throttle valve for closing the latter when said auxiliary resistance is inserted into said rotor circuit, said mechanical coupling means comprising a clutch element on the prime mover, a clutch element on the transmission shaft, spring means normally urging said clutch elements into engagement, electromagnetic means for disengaging said clutch elements when said field structure and said stator are excited, a circuit for said electromagnetic means, said last named circuit being opened by said movable contact member when the same is moved to a position where it interrupts the excitation of said field structure and said stator, such de-energizing of said electromagnetic means permitting said spring means to engage said clutch elements.

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