T. A. EDISON.
ELECTRIC LOCOMOTIVE.

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To all whom it may concern:

Be it known that I, THOMAS A. EDISON, a citizen of the United States, residing at Llewellyn Park, county of Essex, and State of New Jersey, have invented a certain new and useful improvement in Electrically-Propelled Vehicles and Means for Controlling the Same, (Case No. 904,) of which the following is a specification.

The present invention relates to electrically propelled cars or vehicles, and especially to the motor and means for controlling it. The invention consists, first, in an improved construction of the motor; second, in the magnetic power transmitting mechanism between said motor and the car axles; third, in the improved switch for throwing resistance into or out of the car circuits; fourth, in a certain arrangement of circuits on the car embracing the propelling motor, magnetic pulleys and clutches; and the invention consists finally in certain other combinations and devices to be hereinafter set forth.

The invention consists in, first, an improved construction of the motor; second, in the magnetic power transmitting mechanism between said motor and the car axles; third, in the improved switch for throwing resistance into or out of the car circuits; fourth, in a certain arrangement of circuits on the car embracing the propelling motor, magnetic pulleys and clutches; and the invention consists finally in certain other combinations and devices to be hereinafter set forth.

In the accompanying drawings which illustrate the invention, Figure 1 is a side view of a car partially in section. Figure 2 is a central section of the motor which I prefer to use on the car. Figure 3 is a plan view of said motor. Figure 4 is a cross section on the line 4-4 of Figure 3. Figure 4a is an end view of the motor with a protecting shield partially surrounding the magnetic pulley. Figure 5 is a central section of my switch on line 5-5 of Figure 7. Figure 6 is a plan of the box or casing in which the switch is mounted. Figure 7 is a plan of the switch in the casing with the top of the casing removed. Figure 8 is a section of the resistance box carrying the resistance which is placed in the field magnet circuit of the motor. Figure 9 is a view of the same at right angles to Figure 8. Figure 10 is an elevation of the resistances which I use for controlling the magnetic clutches. Figure 11 is a plan view thereof. Figure 12 is a section of one of the rods on which the resistances are wound. Figure 13 is a diagram illustrating the connection between the several resistance coils. Figure 14 is a diagram illustrating the entire arrangement of circuits on the car; and Figure 15 is a diagram showing a different arrangement of the armature circuit connections from that shown in Figure 14. Figure 16 is a view of the motor at right angles to Figure 3 with the pulley shields in place. Figure 17 shows one form of magnetic belt which may be used; and Figure 18 shows another form of magnetic pulley and clutch.

The current for propelling the car may be taken from any suitable conductor, shown in this case as an overhead conductor 1 against which a trolley 2 bears. The motor 3 is preferably supported on the car truck midway between two axles thereof. The motor is preferably constructed substantially as shown on Sheet 2.

4, 4 are end plates serving as yokes to connect the pole pieces 5, of which there are four arranged to surround the armature as clearly shown. Said armature consists of a hub 6 on the shaft 7, an insulating web 8 composed of several insulating rings placed on the hub and bolted together, the core 9, preferably consisting of oxidized iron wire, and an armature coil 10 wound on said core and connected by means of wires 11 to the commutator plates 12, against which the commutator brushes 13 bear in the ordinary manner. These commutator brushes are supported between the pole pieces and armature and the inner face of plate 4, and are insulated from said plate. By being thus supported they are inclosed and protected from mechanical injury. The axis or shaft of the armature is extended in both directions, as indicated at 14, 14', and on each end of said shaft is placed a magnetic pulley 15, 15' consisting of an iron cylinder having one or more grooves 16 around it, in which grooves are wound magnetizing coils.

17, 18 are metal rings insulated from the shaft by a bushing 19. One of said rings is connected to one end of the magnetizing coil 95 of the pulley, and the other ring is connected to the opposite end thereof. When in use, a brush 19' connected with the supply circuit rests in the groove in each of these rings.

In Figure 24 an iron or steel plate 24, bent into a U shape, is shown bolted to the end plate or yoke 4 and surrounding the magnetic pulley 15 on three sides, the fourth side being left wholly or partially open for passage of the
belt. The shield at the opposite end of the
motor shaft would be reversed in position to
accommodate the second belt which extends
to an axle on the opposite side of the motor.

This arrangement is shown in Fig. 16.

As shown in Figs. 1 and 16, a plate 45, is
placed over the outer end of the shield. Said
plate is secured to the shield by bolts in the
same manner as the shield is secured to the
yoke of the motor (see Fig. 4). The plates
45, at each end of the motor are then bolted
to the side beams B of the truck and thus
support the motor.

At some convenient point on the car, pref-
erably under the body as shown in Fig. 1, is
placed a box or case 20 containing resistances
which are used in regulating the car motor.
This case and resistance device are preferably
constructed as illustrated on Sheet 5.

In none or more sides of the box are openings 21,
covering which are brass wire or other screens
22 for the purpose of admitting air to the re-

distance coils, keeping them thoroughly cool
and at the same time protecting them from
mechanical injury. The wires 23 constitut-
ing the resistance coils are wound on several
rods 23' of wood or other material, over each
of which is placed a covering 24 of asbestos.
See Fig. 8. Through the center of the box is
a passage 25, through which the conductors
may be carried. The ends of the box are
preferably double, as shown in Fig. 9, the ends
26 supporting the rods 23', and the ends 27
having an opening 29 through which the ca-
ele is carried to the switches 29, 29' at either
end of the car.

The switches just referred to are construct-
ed as shown in Sheets 1, 3 and 4 of the draw-
ings.

30 is a sheet metal stand resting on the
platform of the car. Within said stand or
case is the clutch resistance 31, the end of the
cable 32 extending to the resistance box 20
and the switch contacts. On an insulating
plate 33 within the stand or within a cham-
ber in the top or cover of the stand the sev-
eral contacts are secured.

It will be seen that in the resistance box 20
there are forty resistance coils. On the plate
33 there is an equal number of contacts 34,
and each of these contacts is connected by a
separate wire in the cable 32 to one of said
 coils. The first of these contacts 34 is quite
long, as seen in Fig. 7, so that the arm 35
will not pass from said first contact onto the sec-
ond contact until arm 39 has passed from 35
over 35' for the purpose hereinafter indicated.

In the clutch resistance shown on Sheet 6
there are five resistance coils, and on the
switch there is an equal number of contact
plates 35, 35', 35'', 35''', 35'''. The connections
between the several coils is shown in Fig. 13.
It will be seen from Fig. 5 that the contacts
35 &c. are on a higher plane than the con-
tacts 34.

36 is a shank or pin rigidly secured to the
insulating plate or block 37, which carries the
switch arm 38 on its lower side, the two ends
of which arm are adapted to bear on the con-
tacts 34 and on the ring terminal 34', and the
switch arm 39 on its upper side, the two
ends of this arm being adapted to make con-
tact with the plates 35' &c. and the opposite
plate 35.

40 is a handle which may be placed on the
pin 36 for the purpose of turning the pin and
the switch arms. This handle is provided
with lugs 41, 42 which fit corresponding slots
in the top of the case, so that the handle must
be inserted in the position shown in Fig. 6. 80
In operating the switch, the handle is moved in
the direction indicated by the arrow in
Fig. 6, and thereby the speed of the car is
regulated in accordance with the position of
the handle as indicated by the words "Slow"
"Fast" &c. on the cover. To speed down the

car, the handle is moved in the reverse direc-
tion back to its original position.

The resistance 31 heretofore referred to as
the clutch resistance is shown in detail on
Sheet 6. On several rods 43, covered with as-
bestos or other heat resisting material 44, the
resistance coils are wound, and are connected
to the terminals 39', 39" &c. in the manner in-
dicated in Fig. 13. When the switch-arm 39
is on the first contact 33', the opposite end be-
ing on the contact plate 36 which is connected
to the clutch circuit, none of the resistance
31 is in circuit; when the switch is turned
bringing 39 onto 33", the first section of the
resistance is brought into the circuit; as the
arm is moved still farther onto 33', the first
two coils are brought into circuit; and so on
for the other contacts and coils. It may be
here stated that the resistances just described
are thrown into or out of a circuit shunting
the magnetic clutches, whereby the clutches
are made to transmit more or less of the power
from the motor to the car axles as hereinafter
set forth. 45, 46 are end plates between which
the rods carrying the resistance coils are sup-
ported.

On the two magnetic power transmitting
mechanisms shown as axles 47 of the car I
mount two magnetic pulleys 49 and two mag-
netic pulleys 48, one clutch and pulley on the
front axle 47 at one end, and one clutch and
pulley on the rear axle at the opposite end
(see Fig. 14), the magnetic pulleys 49 being
in line with the two magnetic pulleys 18, 18'
on the armature shaft and said pulleys being
connected by magnetic belts 50. These may
be plain steel bands, or the belt may consist
of steel bands 50' on which are riveted cross-
braces 50" of soft iron. The magnetic pulleys
49 are constructed like the pulley 15 already
described. The clutches 45 each consist of
two plates facing each other, mounted on the
axle 47, the plate 48' being rigidly secured to
its axle, and the part 48" being loose on said
axle but forming a part of the magnetic pul-
yer 49' or being rigidly connected therewith,
as set forth in my application Serial No. 574,760, filed December 18, 1890. The pulley
has circumferential grooves 49 in which magnetizing coils are wound. The terminals are connected to the two insulated rings 49', against which brushes 49'', which are connected to the supply circuit, bear. By the term "magnetic power transmitting mechanism" I mean a mechanism which when suitably magnetized by a current, or when put in proper working condition, serves to transmit power from the motor to the car axle, but when not magnetized or in such condition slips and fails to transmit the power. In the form of apparatus described the magnetic clutch and the pulley connected to one member of the clutch constitute this transmitting mechanism.

In Fig. 14, 61, 51' are switches for closing the circuit in one direction or the other through the motor armature 10'. These switches are preferably so arranged as to be closed by the handle 40 heretofore described and to be positively opened by removal of said handle, but they may be separately operated switches adjacent to those operated by handle 40. In either case the arrangement is such that the circuit through the armature cannot be reversed without opening the switch at one end of the car and closing a corresponding switch at the opposite end of the car. This renders it impossible for an operator to reverse the current through the motor before it has had time to slow down.

In the diagram Fig. 14 the several parts are designated by the same numerals as in the other figures so far as possible. For simplicity only a few resistance coils 23, and a corresponding number of contacts 34, are shown in said figure, and instead of the contacts 35, 34' of Fig. 7, the wires to which the said contact plates are connected in practice are shown in the diagram connected directly to the switch-arms.

2', Fig. 14, is the wire leading from the trolley to the car circuit. At the point 53 the current divides into three branches, one branch 53 extending through the field magnet of the motor 3 by wire 54 to switch-arm 38 through said arm to the first contact 34 by wire 55 to the first contact 34 at the opposite switch to the arm 38 to wire 56 and to ground through the car wheels or otherwise. The second branch 57 leads to the switch 51 shown closed, thence to wire 58, through the armature 10' of the car motor, to the opposite side of switch 51, to wire 59, to wire 60, through the magnetizing coils of the two clutches 48, thence by wire 61, through the magnetizing coils of the magnetic pulleys 15, 15' and 49, and thence to earth, the armature, the clutch coils and the magnetic pulley coils thus being in series. The third branch 59 leads to the switch 51 shown open; at the point 63 the line 59 branches to the switch-arm 39 (or plate 35) thence to the contact 35', thence by wire 64 to the corresponding contact 35' at the opposite switch, arm 39, wire 65, to wire 61 between the clutches 48 and the magnetic pulleys. This branch as just traced constitutes a circuit of low resistance, that is, a short circuit around the magnetic clutches.

55 are wires leading from the contacts 34 of one switch to the corresponding contacts of the opposite switch and connected to the several resistance coils 33 in the manner indicated in Fig. 14. In Fig. 15 is illustrated an arrangement in which the motor armature circuit is controlled simultaneously with the field magnet and clutch resistances. The terminals of the armature circuit are connected at the right 80 switch to conductors 58', 58'', which are adjacent to conductors 59', 59'', the latter conductors being connected to wires 57 and 59, 62 and 64 respectively. At the left switch the armature is connected to conductors 58', 58'', 85 but said conductors are transposed. The switch-arms 38 each carry two conducting springs or blocks 38' adapted to connect the conductors 58', 58'' &c., but when the switch handle 40 (Fig. 8) is inserted and turned slightly the armature circuit is closed. If the handle is inserted at one switch the armature circuit is closed in one direction, and if the handle is inserted at the other switch the circuit is closed in the opposite direction. Since the handle cannot be removed without turning it back to its initial position, the armature circuit will necessarily be opened by the act of taking out the handle.

The apparatus and circuits having thus been described, the method of operating the car will now be set forth. When the car is on the track and in operation, the motor circuit is continuously closed and the armature is continuously rotating. Suppose the switch apparatus to be in the position indicated by the diagram; the circuit through the motor would be complete but the car would be stationary owing to the complete short circuit around the magnetizing coils of the clutches 48 through which motion is transmitted from the armature shaft to the car axles. When it is desired to start the car, the switch is turned (by means of handle 40) carrying the arm 39 over the contacts 35', 35'' &c., thereby gradually energizing the magnetic power transmitting mechanism and starting the car. As the arm 39 moves over said contacts, the arm 39 moves over the first contact 34 without varying the amount of resistance in the field magnet circuit. As the switch-arm 39 passes from the last contact 35' the switch-arm 38 passes onto the second contact 34, thereby throwing the first resistance coil 23 into the field magnet circuit. As said arm is moved along to the next contact, the second resistance coil is thrown into the field magnet circuit, and so on successively for all the coils, thereby gradually weakening the strength of the field magnet and increasing the speed of
the motor armature. To slow down the car, the movement of the switch-arms 38, 39 would be reversed as heretofore stated.

In practice I prefer to have the armature revolve at a speed sufficient to propel the car about four miles an hour when the clutch is completely magnetized and when none of the resistance coils are in the field magnet circuit.

To regulate the speed below four miles an hour, the clutch is allowed to slip more or less by adjusting the resistance in the clutch shunt circuit. To regulate the speed above four miles an hour, the resistance of the field magnet circuit is adjusted as above described.

Having thus described the invention, what I claim is—

1. The combination, in an electrically propelled vehicle, of a motor, pulleys on the motor shaft, magnetic pulleys on two of the vehicle axles, magnetic belts between said motor shaft and pulleys on the axles, and magnetic clutches between the axles and the magnetic pulleys, substantially as described.

2. The combination of a vehicle, a motor, a shaft for the motor having one or more pulleys, a shield for each of said pulleys and a connection between the shield and the vehicle for supporting the motor, substantially as described.

3. The combination, in a switch, of a plate or block and means for turning it, said plate carrying two switch-arms at an angle to each other and in different planes, one of said arms co-operating with one series of contacts, and the other of said arms co-operating with a second series of contacts, substantially as described.

4. The combination of a vehicle, a motor for propelling it, a switch at each end of the vehicle for controlling the speed thereof, a switch at one end of the vehicle for closing the circuit through the motor in one direction only, and a switch at the opposite end of the vehicle for closing the circuit through the motor in the opposite direction only, substantially as described.

5. The combination of a vehicle, a motor for propelling it, a switch at each end of the vehicle for controlling the speed thereof, a switch at one end of the vehicle for closing the circuit through the motor in one direction only, and a switch at the opposite end of the vehicle for closing the circuit through the motor in the opposite direction only, and means for operating either of said switches at will, substantially as described.

6. The combination of a magnetic clutch, a coil for magnetizing the same, a shunt around said coil, independent of the motor circuit and a switch for controlling the shunt, whereby the condition of the shunt can be varied without affecting the speed of the motor, substantially as described.

7. The combination with a vehicle and a motor for propelling it, of a magnetic clutch between the motor shaft and an axle of the vehicle, a shunt around said magnetic clutch, independent of the motor branch, and a switch for varying the resistance in said shunt, substantially as described.

8. The combination of a motor, a magnetic clutch, a shunt around the clutch, a resistance, a switch having two switch-arms or devices, contacts for each of the arms, one of the arms serving to throw resistance into or out of said shunt circuit, thereby varying the speed of the driven shaft without varying the speed of the motor, the other switch-arms serving to regulate the speed of the motor after all of said resistance has been successively thrown into the shunt circuit, substantially as described.

9. The combination of a vehicle, a motor for propelling it, switches comprising circuit contacts and co-operating switch arms on opposite ends of the vehicle, a regulating resistance for the motor supported on the vehicle, connections from said resistance to the two switches, and means for throwing said resistance into or out of the motor circuit, substantially as described.

10. The combination of a vehicle, a propelling motor in which the field magnet and armature are in multiple arcs, a single resistance box supported on the vehicle and connected to switches at both ends of the vehicle, and means at said switches for throwing said resistance into or out of the field magnet circuit, substantially as described.

11. The combination of the box or case having double ends, the rods supported between the inner walls of the ends, the resistance coils on said rods, and a passage through the resistance device for the conductors, substantially as described.

12. The combination, in a resistance device, of an insulating case, insulated rods in said case supported between plates as described, coils on said rods, and a passage through the resistance device for the conductors, substantially as described.

This specification signed and witnessed this 20th day of December, 1890.

THOS. A. EDISON.

Witnesses:
CHARLES M. CATLIN,
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