No. 638,522. Patented Dec. 5, 1899.

F. B. RAE.

ELECTRIC MOTOR CONTROLLING SYSTEM.

(Application filed Feb. 18, 1898.)

(No Model.)

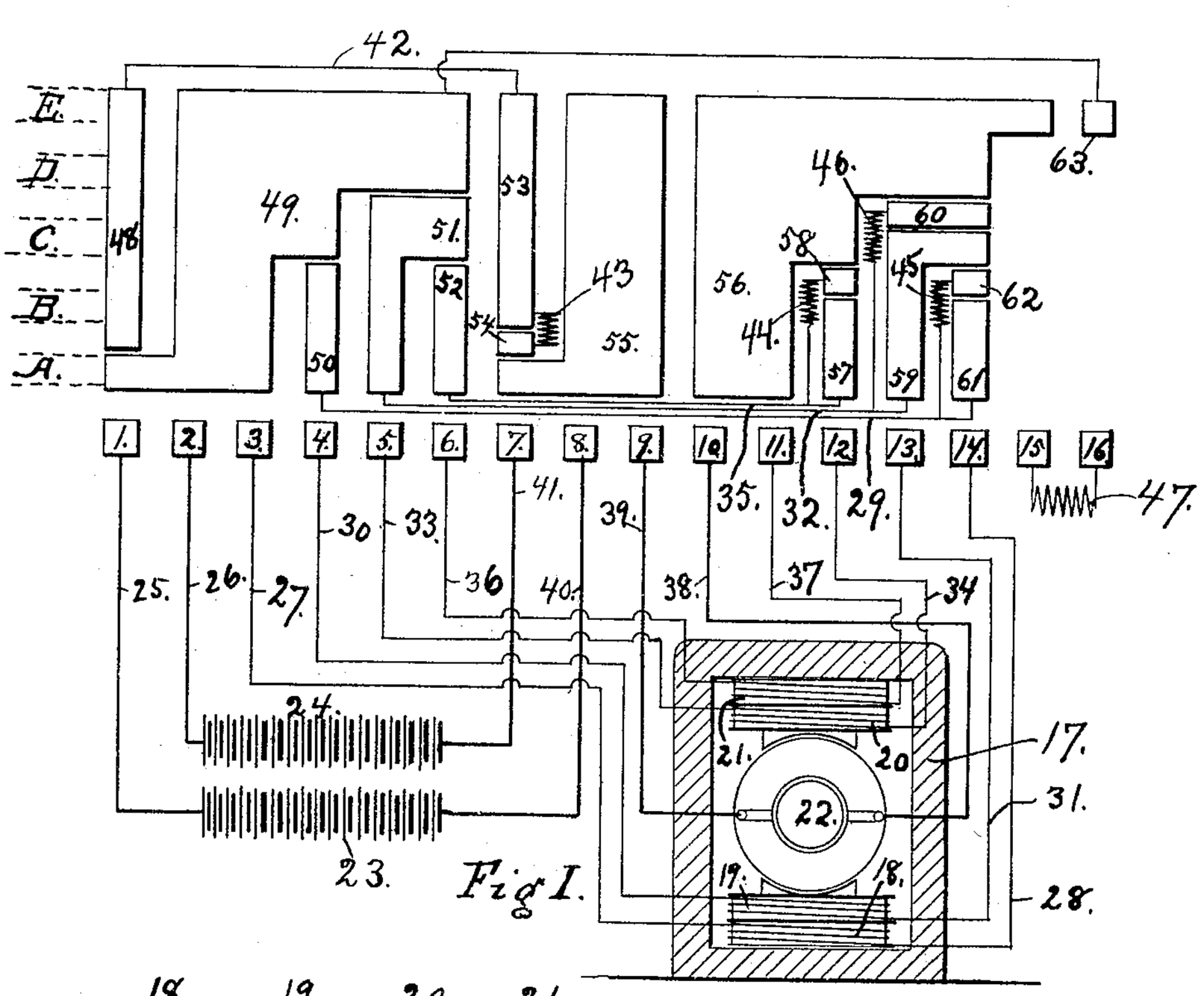

Fig I.

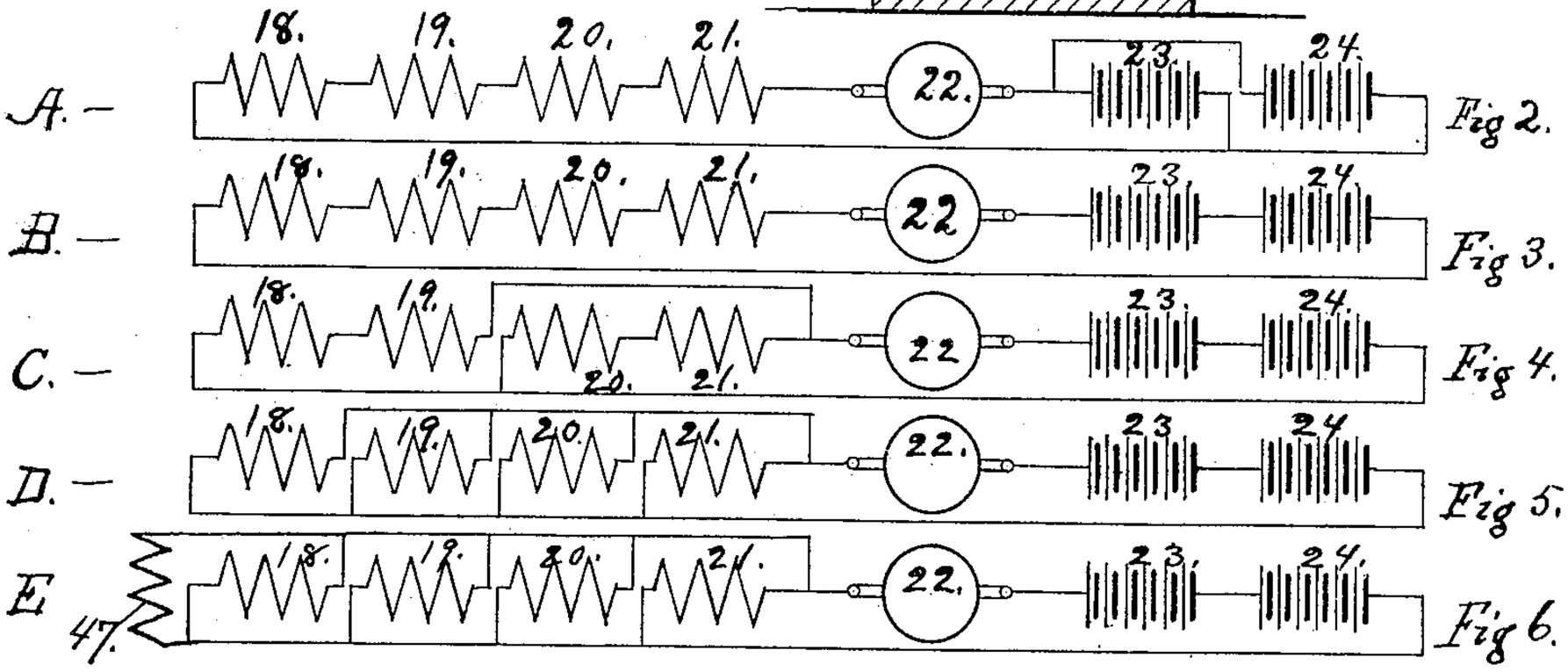

Fig 2.

Fig 3.

Fig 4.

Fig 5.

Fig 6.

Witnesses:
H. J. Sinclair.
Chester B. Baird

Inventor:
Frank B Rae
By Attorney
Paul Synnestvedt.

UNITED STATES PATENT OFFICE.

FRANK B. RAE, OF CHICAGO, ILLINOIS.

ELECTRIC-MOTOR-CONTROLLING SYSTEM.

SPECIFICATION forming part of Letters Patent No. 638,522, dated December 5, 1899.

Application filed February 18, 1898. Serial No. 670,729. (No model.)

To all whom it may concern:

Be it known that I, FRANK B. RAE, a citizen of the United States, residing in Chicago, Cook county, Illinois, have invented certain new and useful Improvements in Electric-Motor-Controlling Systems, of which the following is a specification.

My invention has particular relation to traction-motors designed to be used under conditions where there is need of frequent starting and stopping, acceleration, or hill-climbing, or where, in brief, a considerable tractive effort or pull is required. It might also be used in connection with elevators or other like classes of service.

More specifically, my invention contemplates the use of a commutating-switch controlling an arrangement of a source of electricity and a plurality of field-magnet coils either in series, in series multiple, or in multiple arc.

My invention further contemplates an arrangement of the field-coils of the motor, the magnetic circuit, and the source of electrical supply in such a manner as to obtain a very large magnetization of the field part of the motor with a comparatively small amount of current, whereby I obtain a very great starting effect or torque to overcome the inertia or the load upon the motor during the periods of starting and acceleration, which is especially desirable in all cases where the motor is subjected to a heavy pulling strain.

Another object of my invention is the combination, with a source of electricity, a motor, and a commutating-switch, of a plurality of field-magnet coils on the motor and segments on the commutating-switch connected with contacts constructed to permit the field-magnet coils to be connected with such source of electricity either in series, in series multiple, or in multiple arc, as may be desired.

Another object of my invention is the provision of a plurality of electrical supply sources in combination with a motor having a plurality of field-magnet coils and a commutating-switch and connections and circuits whereby the plurality of electrical supply sources may be placed in circuit with such field-magnet coils either in series or in multiple arc.

Another object of my invention is the provision of a source of electricity, an armature-coil, and a plurality of separate field-magnet coils on a motor, combined with separate connections from the field-magnet coils or the armature-coil and from the source of electricity to a commutating-switch.

A still further object of my invention is the construction of a commutating-switch having segments thereon and contacts in connection therewith having resistances adapted to be included in effecting the various combinations of circuit and to be excluded when such circuits are finally effected, whereby continuity of the circuits is maintained during the movement from one to the other without any sparking or short-circuiting or the troubles resulting therefrom.

Still another object of my invention is the provision of a commutating-switch, in combination with a motor having a plurality of field-coils and resistance connected between the switch-segments in such manner that commutation of the field-coils in series, in series multiple, and in multiple arc may be effected without either short-circuiting or interrupting the continuity of the circuit, and consequently without waste of current, sparking, or corrosion of the contacts.

The above, as well as such other objects as may hereinafter appear, I attain by the construction which I have diagrammatically illustrated in preferred form in the accompanying drawings, in which—

Figure 1 shows the development of my commutator-switch with the segments, contacts, and circuits connected therewith. Fig. 2 shows, diagrammatically, the arrangement of the different circuits in the first position of the switch; and Figs. 3, 4, 5, and 6 represent the arrangement of the circuits in the second, third, fourth, and fifth positions, respectively.

Referring now more particularly to Fig. 1, it will be seen that I have provided a plurality of stationary contacts 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, and 16, arranged so that they will be brought into circuit with the metal segments numbered 48 to 63, inclusive, as the latter are successively moved from one position to another. The segments are preferably arranged cylindrically about a rotating drum; but for the purpose of illustra-

tion I have shown them as developed upon a flat surface.

At 17 I have shown the magnetic field of a motor wound with four separate coils 18, 19, 20, and 21.

22 is the armature of the motor, and 23 and 24 are each a series of storage-battery cells having approximately the same electromotive force.

The operation of my invention is as follows: Supposing the commutating-switch be moved until the contacts 1 to 14, inclusive, rest upon the segments 49, 50, 51, 52, 55, 56, 57, 59, and 61 in the position indicated by the two lines marked A to the left of the figure. In this position one pole (say the positive pole) of battery 23 is connected by wire 25 to contact 1 and the corresponding pole of battery 21 is connected by wire 26 to contact 2, the two contacts being connected together through the segment 49. A current will flow from this segment 49 to contact 3, through wire 27, field-coil 18, and wire 28 to contact 14, through segment 61, wire 29, and segment 50 to contact 4, through wire 30, field-coil 19, and wire 31 to contact 13, through segment 59, wire 32, and segment 51 to contact 5, through wire 33, field-coil 20, and wire 34 to contact 12, through segment 57, wire 35, and segment 52 to contact 6, through wire 36, field-coil 21, and wire 37 to contact 11, through segment 56, contact 10, wire 38, motor-armature 22, and wire 39 to contact 9 and segment 55, and from segment 55 to contacts 7 and 8, returning through the wires 40 and 41 to the negative poles of the batteries 23 and 24.

In the position described the switch connections correspond with the diagram shown in Fig. 2, in which all of the field-coils of the motor are connected together in series and are supplied by current from the batteries, which are connected in multiple of two groups. Under this condition of the several parts the electromotive force, tending to pass a circuit through the several field-windings, will be equal to that of one set of the cells only, and the resistance of the field-coils in series will be such that the amount of current flowing at this time will not be excessive, not exceeding at any time the normal current output of the batteries. At the same time the number of effective turns of the coils upon the field-magnet is sufficient with this normal current output to produce very great field magnetization. While the armature of the motor will therefore revolve at a comparatively very low speed, (because of the low-impressed electromotive force of the cell and the excessive magnetization of the field-iron,) it will exert, even at the very beginning, a very great torque or starting effort.

It is next desired to produce greater speed of the motor-armature, and this I accomplish by increasing the impressed electromotive force by arranging the batteries 23 and 24 in series with each other. In making this change it is desirable that the circuit through the field-coils shall not be interrupted and also that the battery shall not be short-circuited, for any interruption of the field-coil circuit would produce sparking, and short-circuiting of the battery is of course wasteful of current and destructive to the cells themselves.

To secure the change desired, the switch is moved from the position A to the position B until the fixed contacts rest upon the various segments between the lines indicated by B. During the passage of the segments from the position A to the position B it is to be noted that the contact 7 is first brought into connection with the small segment 54, and at this instant current will flow from the battery 23 and the connections with which it is then in circuit through the resistance-coil 43 and the several field windings and circuits, as before. There is thus interposed in the battery-circuit a resistance which serves to bridge over the break in the circuit, while the further movement of the parts to the position marked B brings the contacts 7 upon the segment 53, thereby cutting the resistance 43 out of the circuit again and effecting the desired commutation of the cells 23 and 24 without actually breaking the circuit, without sparking, and without any short-circuiting or injury of the batteries themselves.

The condition of the several circuits in the position B is diagrammatically illustrated in Fig. 3, the batteries being connected in series and the electromotive force impressed upon the motor being double and the speed of the armature thereby increased, no change having been made in the arrangement or connection of the several coils of the field-magnet.

In order now to further increase the speed of the motor-armature, I move the parts to the position marked C, illustrated diagrammatically in Fig. 4, thereby decreasing the effective turns upon the field-magnet, arranging the four coils in two multiple groups containing two coils in series in each group. In passing from the position B to the position C breaking or sparking of the current through the field-coils by the commutation of the same is prevented by a provision similar to that already described above, the contacts 12 and 14 during the movement of the switch first resting upon the segments 58 and 62, respectively, at which time there are interposed in the circuit resistances 44 and 45. The arrangement of the circuits during this movement may be traced as follows: from the positive pole of batteries 23 to contact 1, segment 48, wire 42, segment 53, contact 7, wire 41, through battery 24, wire 26, contact 2, segment 49, contact 3, wire 27, field-magnet 18, wire 28, contact 14 to segment 62, thence through resistance 45 to wire 29, to segment 50, contact 4, wire 30, field-coil 19, wire 31, contact 13, segment 59, wire 32, segment 51, contact 5, wire 33, field-coil 20, wire 34, contact 12, segment 58, resistance 44, wire 35, segment 52, contact

6, wire 36, field-coil 21, wire 37, contact 11, segment 56, contact 10, wire 35, through armature 22, wire 39, contact 9, segment 55, and contact 8 to the negative pole of battery 23, thus completing the circuit, in which are interposed resistances 44 and 45, whereby the combination thus far has been affected without interrupting the circuit or short-circuiting any part. The completed movement of the switch to the position E brings the contact 12 upon segment 56, eliminating the resistance 44, and the contact 14 upon the segment 59 eliminating the resistance 45.

The arrangement of the several circuits after the completion of the above movement is diagrammatically shown in Fig. 4, the field-coils 18 and 19 being connected in series and the field-coils 20 and 21 also connected in series, but the free ends of the two sets or series being connected in multiple arc across the cells 23 and 24, which are kept in series connection, the armature 22 being interposed between the coils and the cells. By this arrangement the effective turns upon the field-magnet are reduced one-half, thus lessening the magnetization thereof and increasing the speed of the armature.

If it be desired now to further increase the speed of the motor-armature, this may be accomplished by further commutation of the field-coils through further movement of the switch to the position marked D. During this movement of the segments the contacts 13 and 14 rest upon the segment 60, by which there is interposed in the circuit the resistance 46, which, in the manner already described, prevents short-circuiting or breaking of the continuity of the circuit. When this movement is completed and the segments are brought in contact along the line D, the resistance 46 is removed from the circuit and the arrangement of the several parts in the position now reached is shown in Fig. 5, the coils 18, 19, 20, and 21 being connected in parallel or multiple arc across the batteries 23 and 24 with the armature of the motor interposed. In this position the effective turns upon the field-magnet are reduced to one-quarter the number that obtain when they are all connected in series, as in Figs. 2 and 3, and the further decrease of magnetization in the field thereby obtained again increases the speed of the motor-armature.

If it now be desired to get a still further increase in the speed, it can be done by moving the parts to the position marked E, illustrated diagrammatically in Fig. 6. In this position I provide and connect a resistance 47 between the contacts 15 and 16, which by the last-mentioned movement of the switch is connected as a shunt across the several windings of the field-magnet, diverting a part of the current previously flowing through such field-windings and reducing still more the magnetization of the field.

In the practice of my invention I am not compelled to follow the exact arrangement of contacts, segments, or details shown, for, as will be plain to any one skilled in the art, a great number of similar combinations of segments, contacts, and details could be constructed so as to produce the same results as I accomplish without departing materially from the spirit of my invention, and I wish to be understood as including all such equivalent arrangements as are clearly within the scope of my claims.

What I claim as new, and desire to secure by Letters Patent, is—

1. The combination with a motor and a commutating-switch, of two sources of electricity, an armature-coil, and a plurality of separate field-magnet coils on said motor, of separate connections from said field-magnet coils, from said armature-coil and from said sources of electricity to said commutating-switch, substantially as described.

2. The combination with a plurality of electrical supply sources, of a motor having a plurality of field-magnet coils, a commutating-switch, and connections and circuits whereby the plurality of electrical supply sources may be placed in circuit with said field-magnet coils, either in series or multiple arc, substantially as described.

3. The combination with a plurality of groups of storage batteries, of a motor having a plurality of field-magnet coils, a commutating-switch, and connections and circuits whereby the plurality of batteries may be placed in circuit with said coils, either in series or in multiple arc, substantially as described.

4. The combination with a commutating-switch, segments thereon, contacts in connection therewith, a motor, and a plurality of field-coils on said motor, of resistances connected between said segments in such manner that commutation of the field-coils in series, in series multiple, and in multiple arc may be effected without either short-circuiting or interrupting the continuity of the circuit, substantially as described.

5. The combination with a plurality of electrical supply sources, of a commutating-switch, a motor, a plurality of separate field-magnet coils on said motor, an armature-coil, and separate connections from said armature-coil, from said field-magnet coils, and from each of said electrical supply sources to said commutating-switch, substantially as described.

FRANK B. RAE.

Witnesses:
HESTER B. BAIRD,
PAUL SYNNESTVEDT.