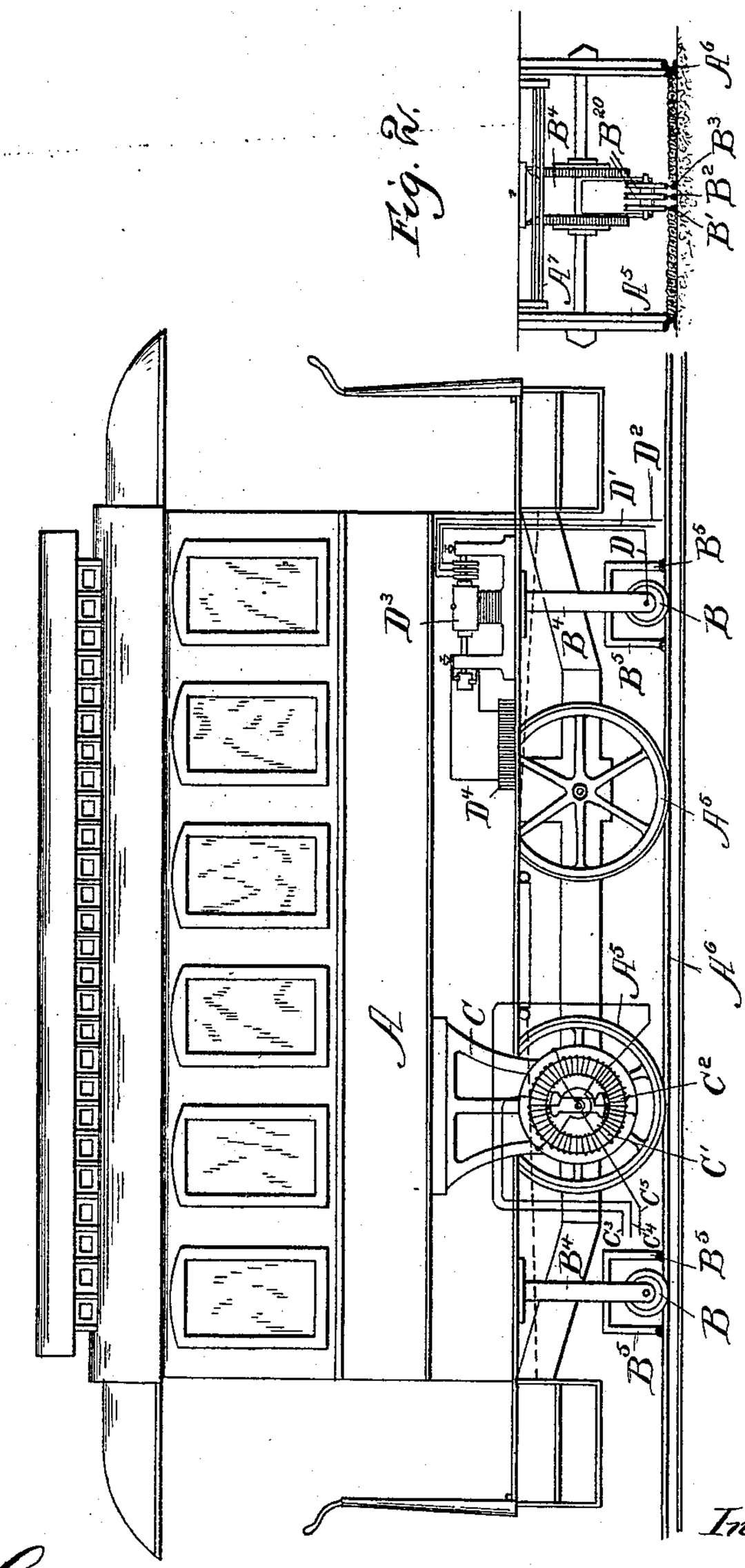
(No Model.) 5 Sheets—Sheet 1

# F. B. BADT.

## MULTIPHASE RAILWAY SYSTEM.

No. 489,597. Patented Jan. 10, 1893.

Fig. 1.

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(No Model.) 5 Sheets—Sheet 2.

# F. B. BADT.

## MULTIPHASE RAILWAY SYSTEM.

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Fig. 16.

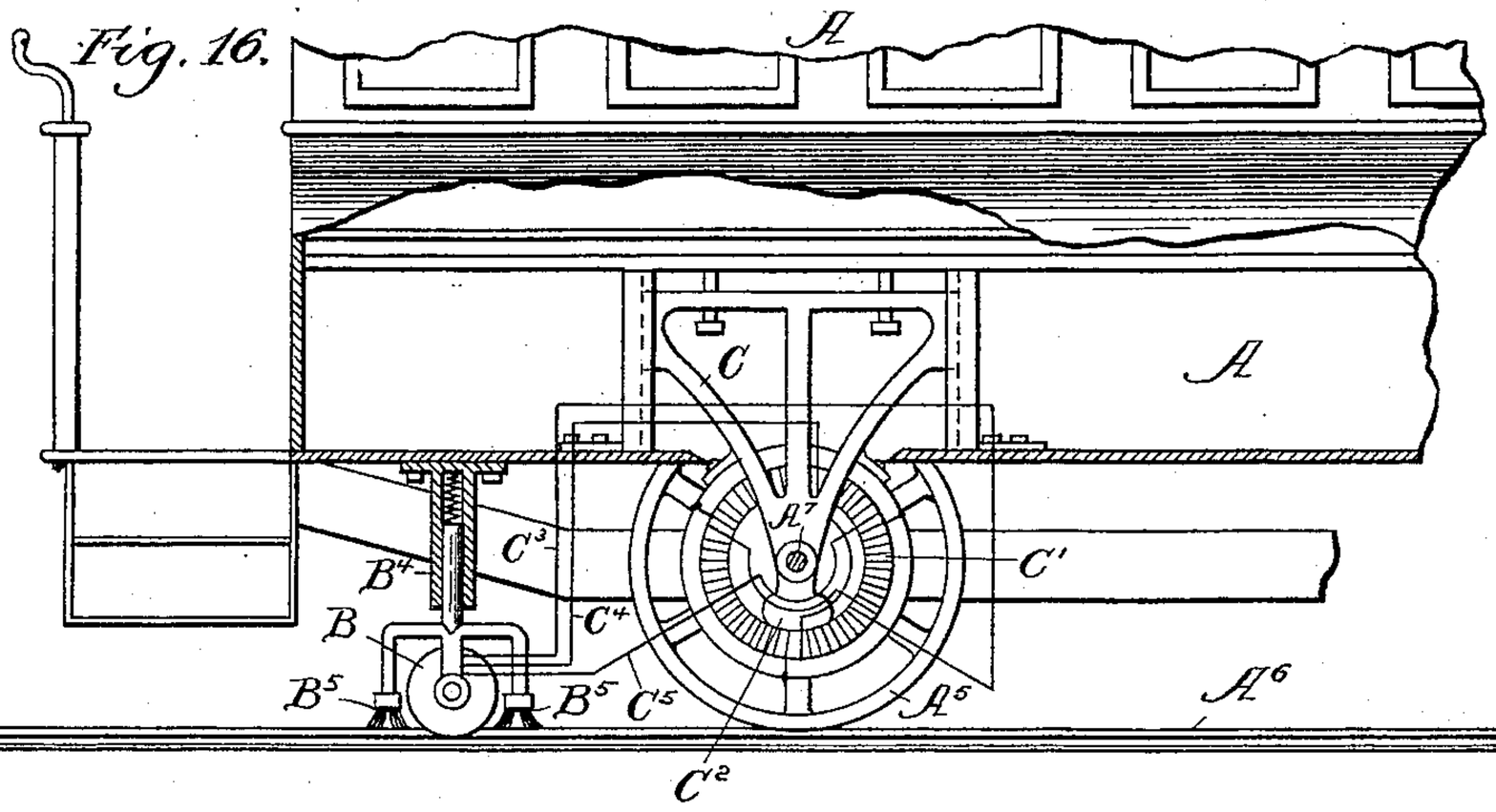



Fig. 9.

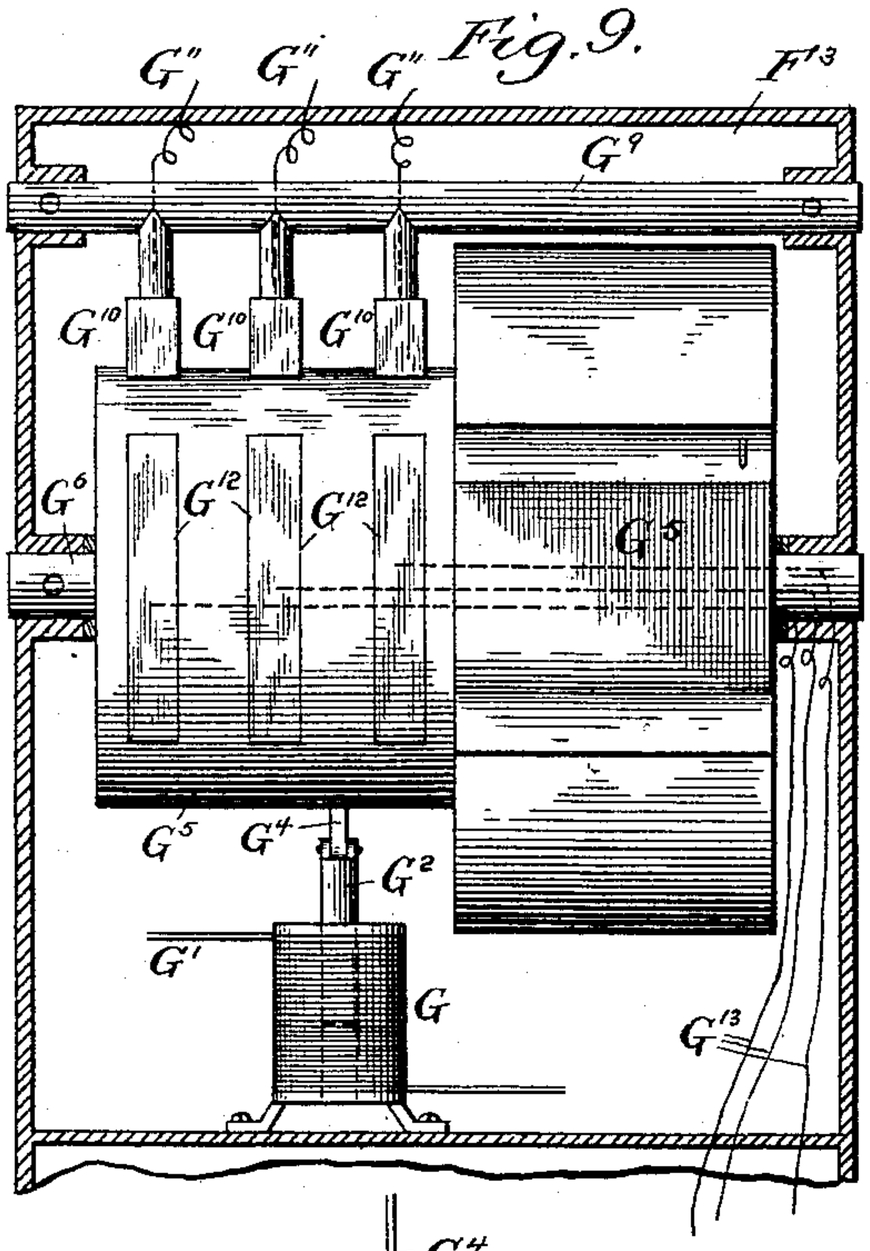



Fig. 10.

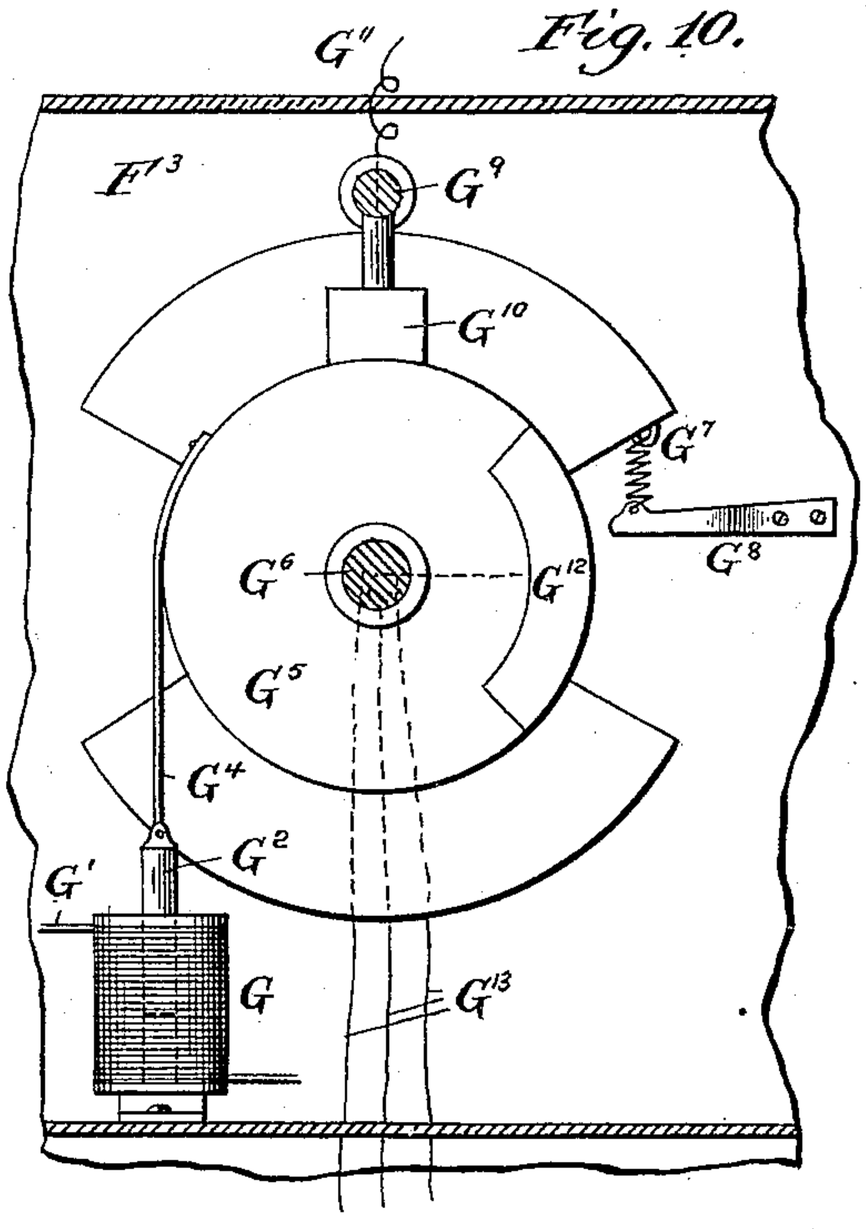
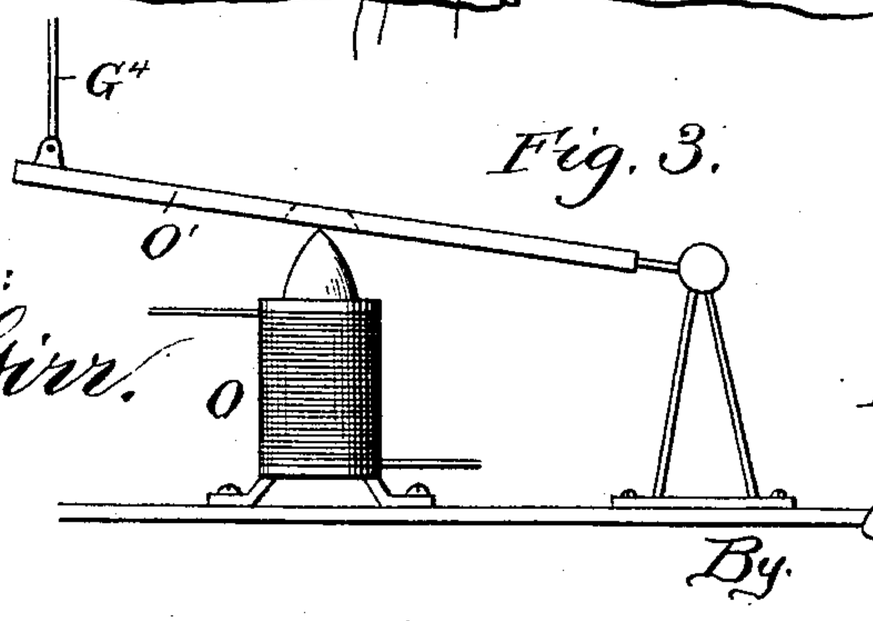



Fig. 3.

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(No Model.) 5 Sheets—Sheet 3.

# F. B. BADT.

## MULTIPHASE RAILWAY SYSTEM.

No. 489,597. Patented Jan. 10, 1893.

Fig. 4.

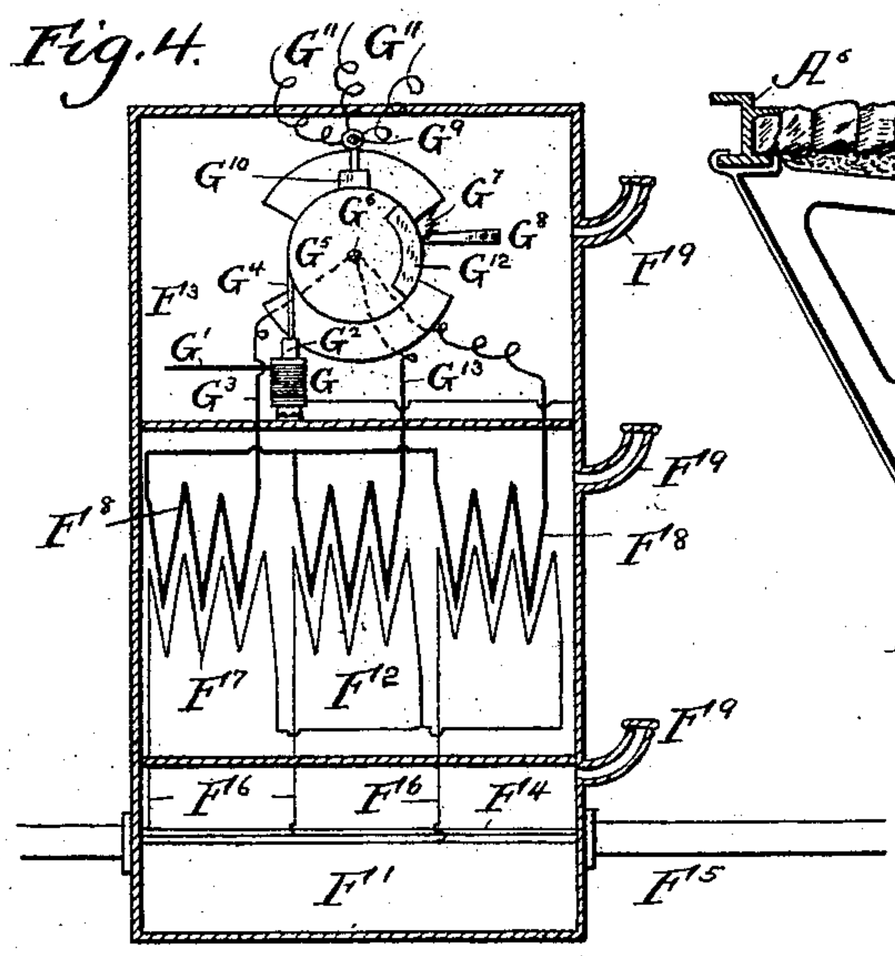



Fig. 13.

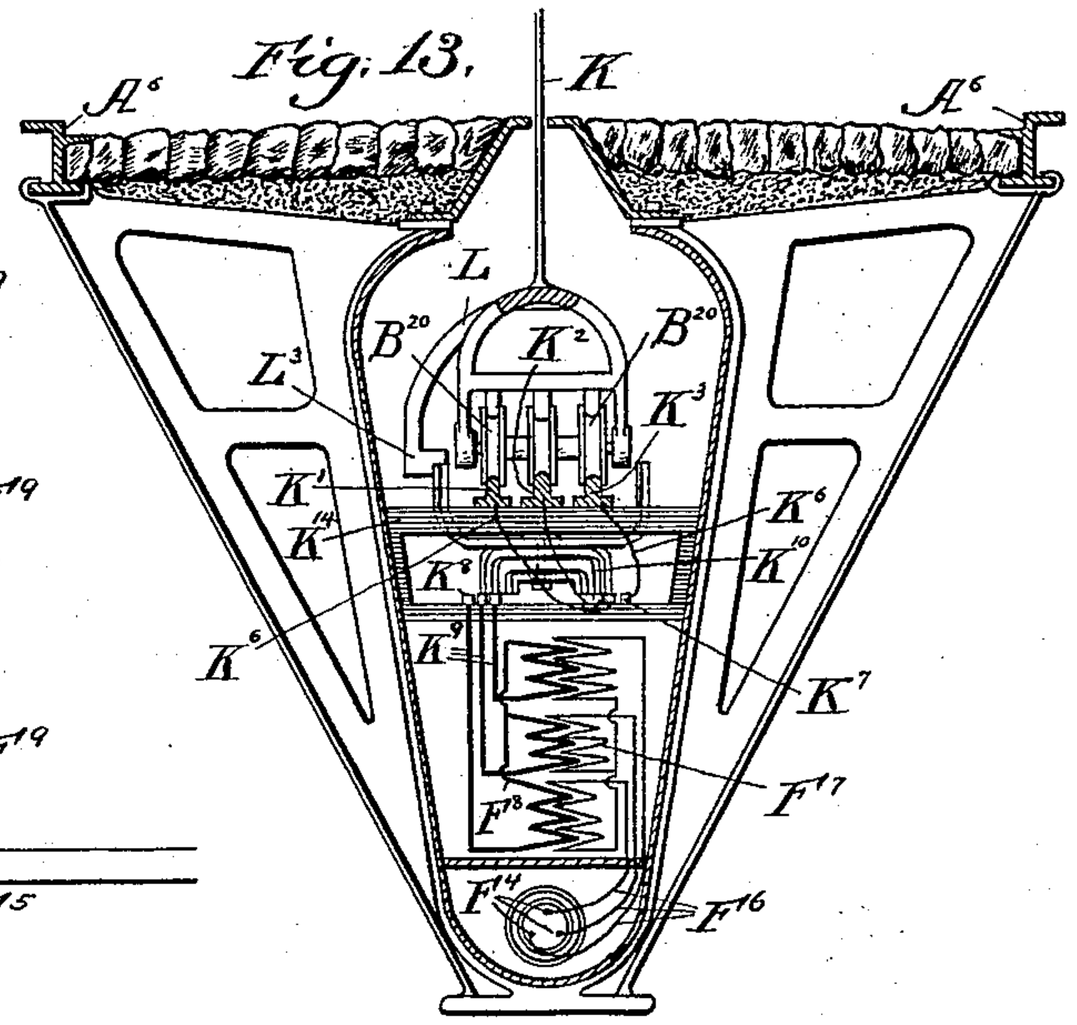



Fig. 11.

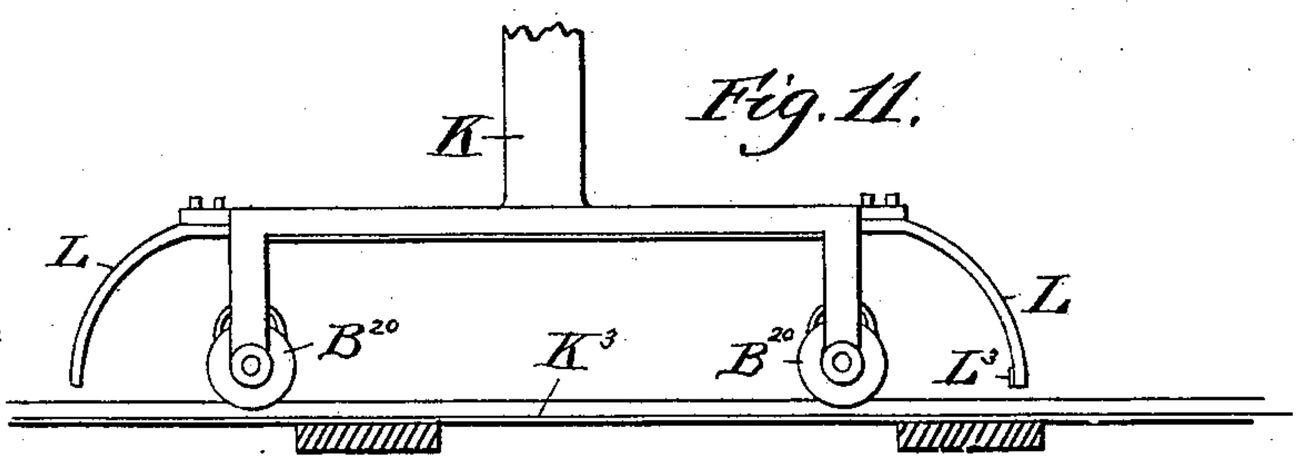



Fig. 14.

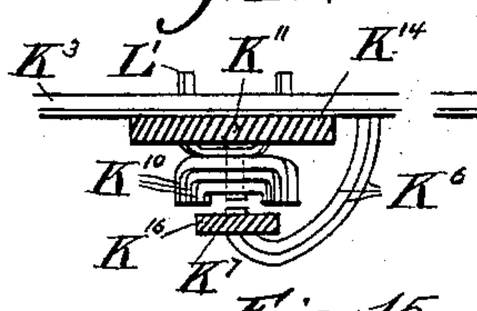



Fig. 15.

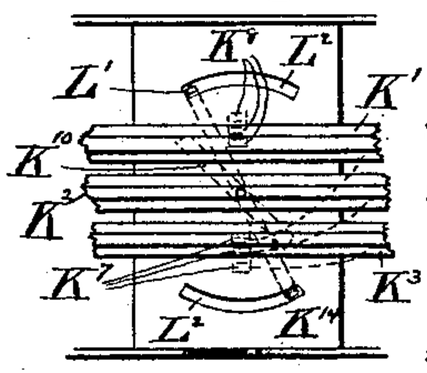
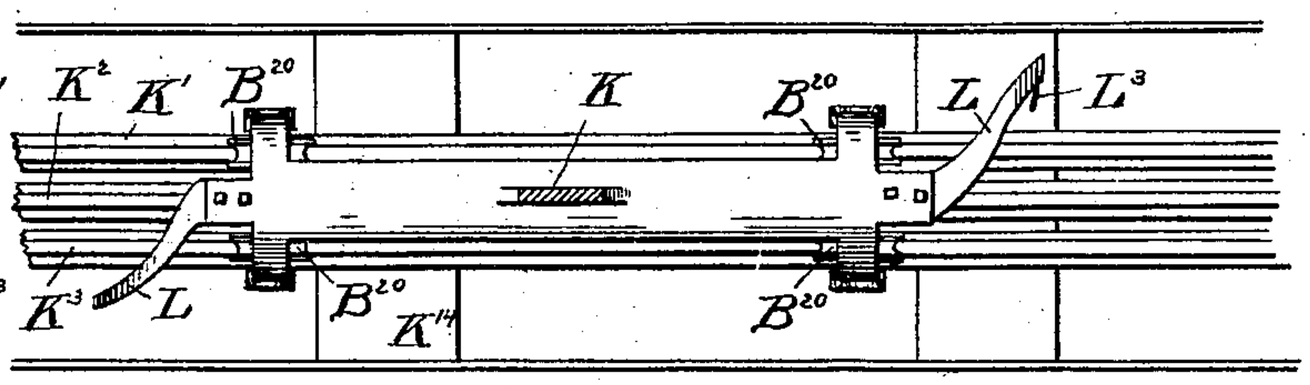



Fig. 12.

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(No Model.) 5 Sheets—Sheet 4.

# F. B. BADT.

## MULTIPHASE RAILWAY SYSTEM.

No. 489,597. Patented Jan. 10, 1893.

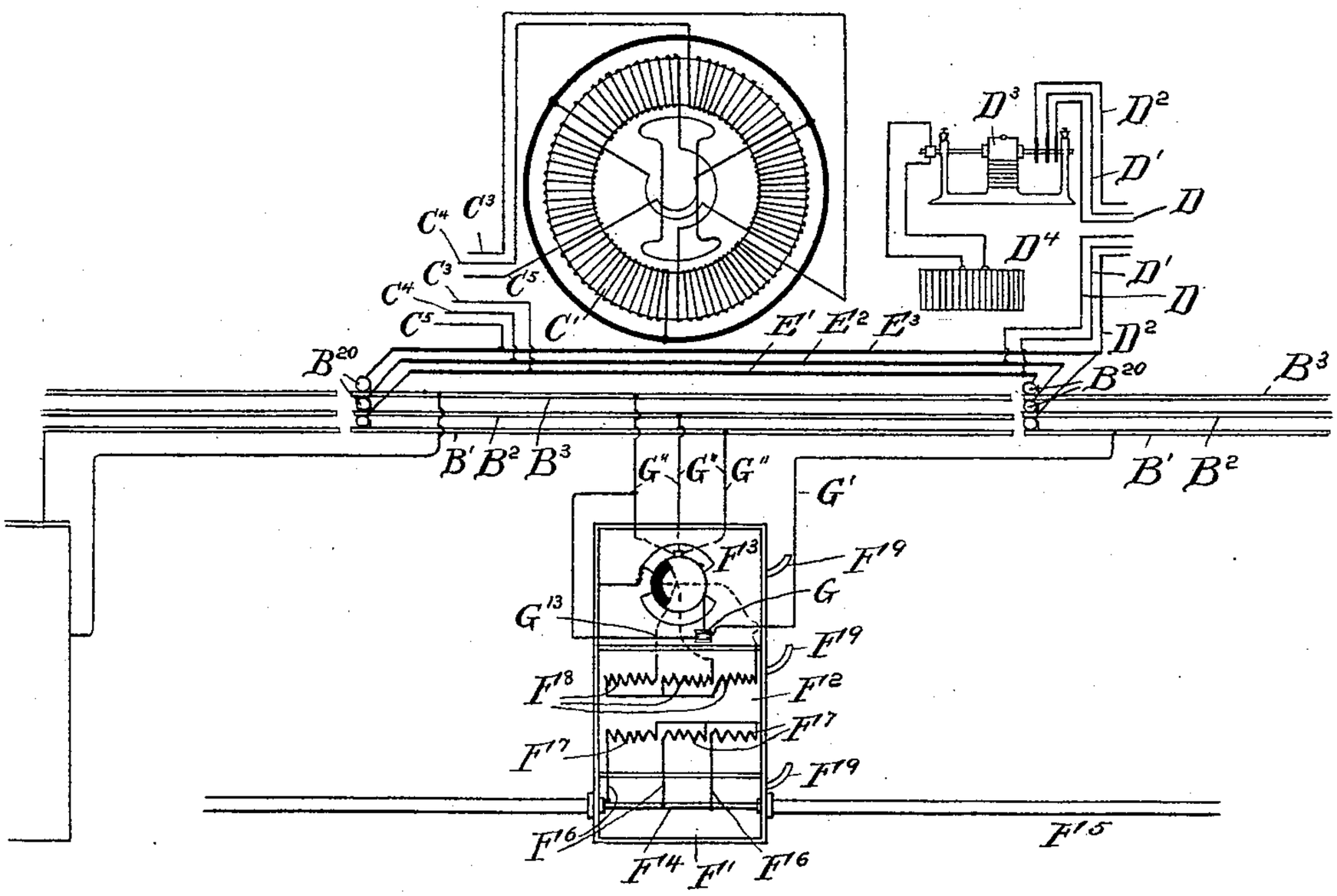


Fig. 5.

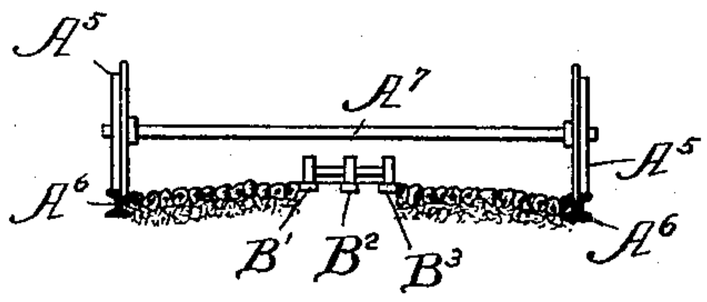


Fig. 6.

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(No Model.) 5 Sheets—Sheet 5.

# F. B. BADT.

## MULTIPHASE RAILWAY SYSTEM.

No. 489,597. Patented Jan. 10, 1893.

Fig. 7.

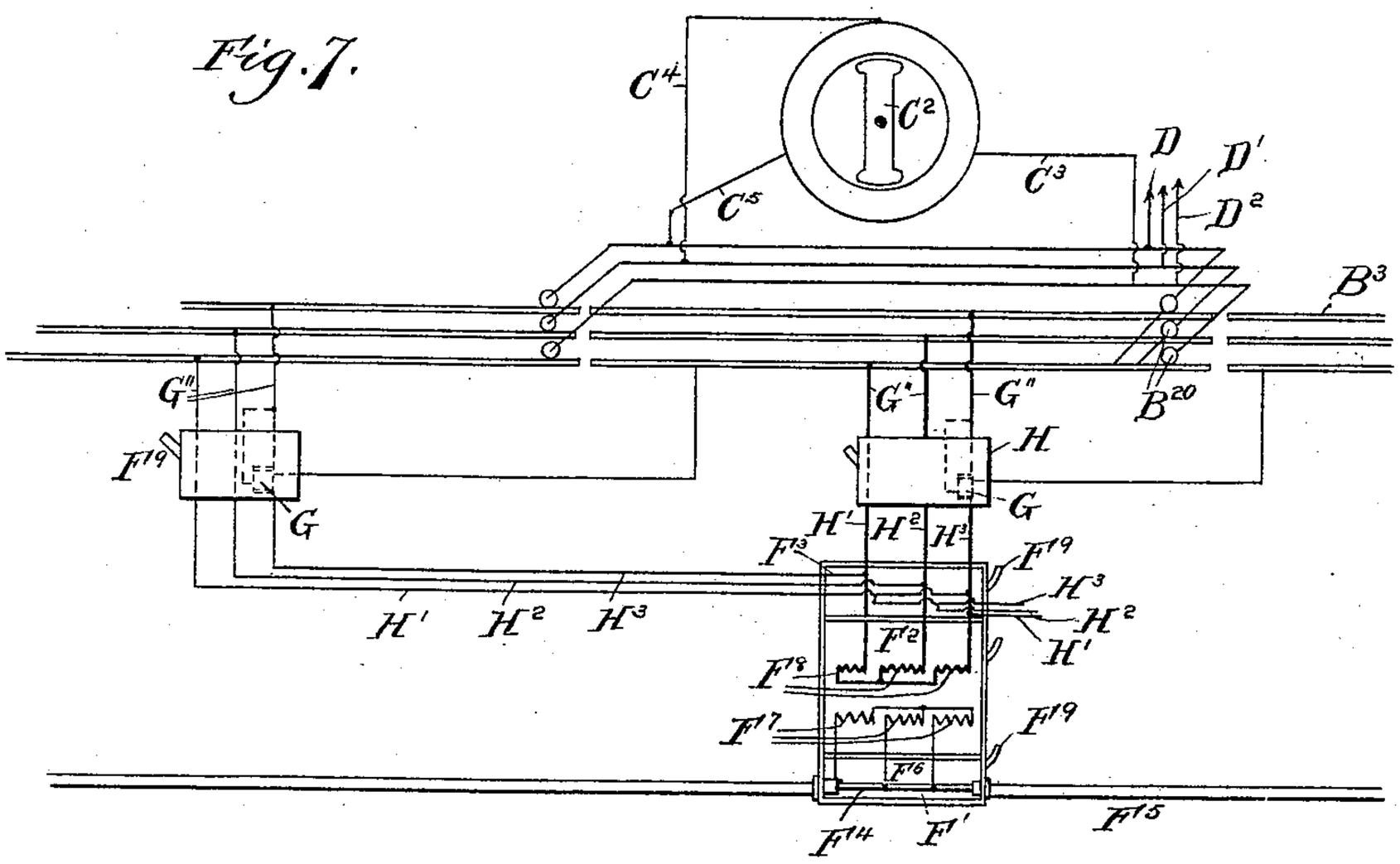
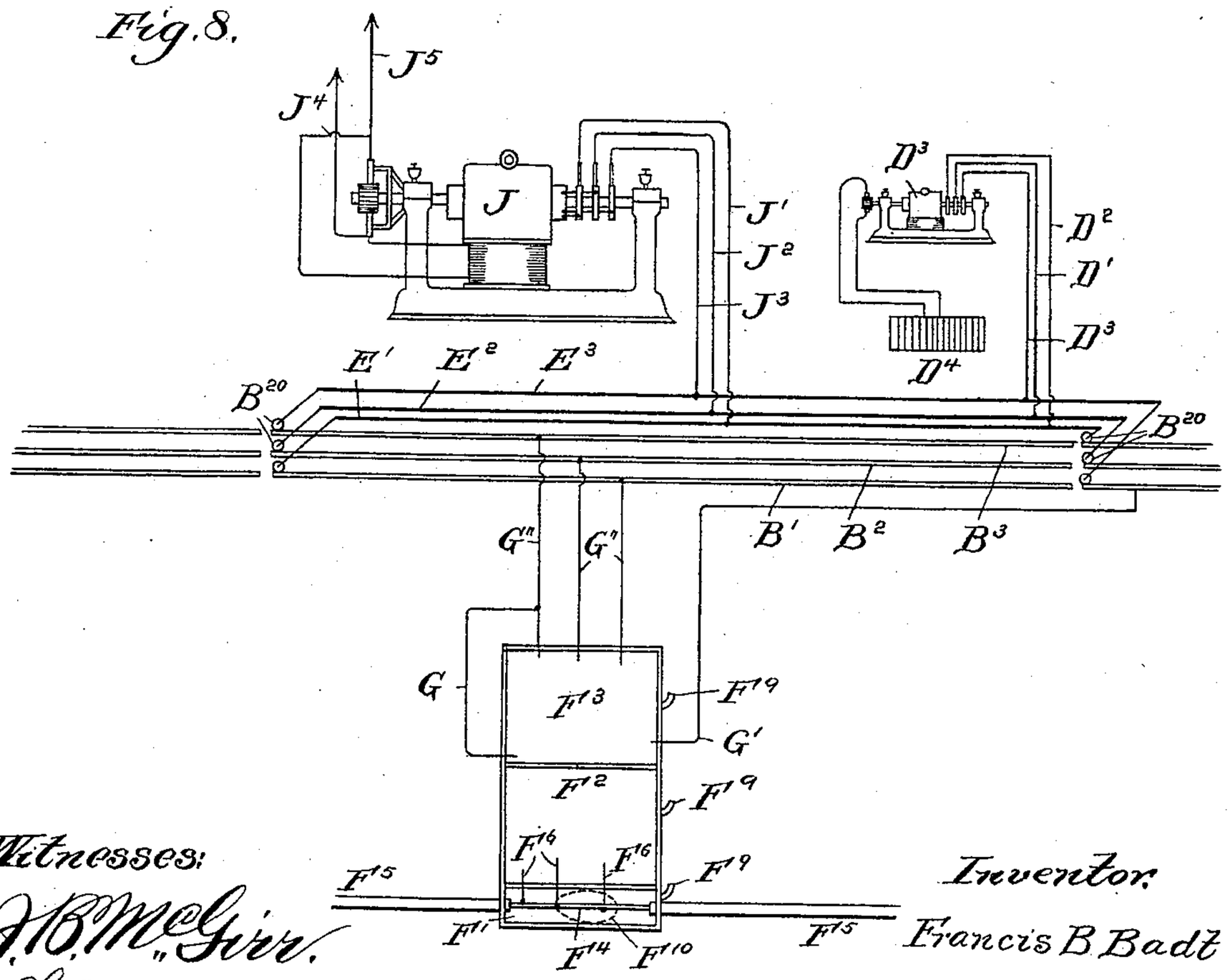



Fig. 8.

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# UNITED STATES PATENT OFFICE.

FRANCIS B. BADT, OF CHICAGO, ILLINOIS.

## MULTIPHASE RAILWAY SYSTEM.

SPECIFICATION forming part of Letters Patent No. 489,597, dated January 10, 1893.

Application filed February 19, 1892. Serial No. 422,160. (No model.)

*To all whom it may concern:*

Be it known that I, FRANCIS B. BADT, a subject of the King of Prussia, residing at Chicago, Cook county, Illinois, have invented a new and useful Improvement in Electric Street-Railways, of which the following is a specification.

My invention relates to improvements in electric street railways and particularly in the means for and methods of supplying currents, especially multiphase currents, from main conductors or underground cables to moving cars. It is illustrated in the accompanying drawings, wherein:

Figure 1 is a view of a car partly in section and partly in elevation showing the general arrangement of some of the features of my invention on the car. Fig. 2 is a cross section through a portion of the car. Fig. 3 is a detail of electric switch magnet. Fig. 4 is an enlarged diagrammatic view of switch and converter box. Fig. 5 is a diagrammatic view of the various parts of the car and underground system in their relative vertical positions. Fig. 6 is a cross sectional view of the track showing the position of surface conducting rails relative to track rails. Fig. 7 is a diagrammatic view showing one transformer or converter utilized for supplying two or more successive sections of conducting rails. Fig. 8 is a diagrammatic view showing wires leading to a direct current motor on the car and to be operated by means of a special motor transformer on the car and actuated from the multiphase system, also a battery and motor transformer to generate multiphase currents on the car to operate the switches. Figs. 9 and 10 are details of the electric switch. Figs. 11 and 12 are side and plan views of portions of the mechanical switch, showing relations of the parts when used in connection with a conduit. Fig. 13 is a transverse section through the conduit. Figs. 14 and 15 are detail views partly in section of the mechanical switch in the conduit. Fig. 16 is a detail of car wheel, armature, &c.

Like parts are indicated by the same letter in all the figures.

A is the car.

$A^5$ are the traction wheels of the car resting upon the rails $A^6$ and carried by the axle $A^7$.

$B^{20}$ $B^{20}$ are the trolley wheels, adapted to engage the surfaces of the contact rails $B'$ $B^2$ $B^3$, and carried in a bracket or hanger $B^4$ depending from the bottom of the car or otherwise supported thereon.

$B^5$ $B^5$ are clearing or contacting brushes, if desired to be used for that purpose, or scrapers before and behind the trolleys.

C is a bracket from the car which supports the cores for the fixed armature windings C', and $C^2$ is the rotating field magnet within this armature winding and secured upon the shaft so that as it rotates the shaft or axle is rotated and the car is driven.

$C^3$ $C^4$ and $C^5$ are the three conductors which constitute the three armature coils and which are connected each with one of the trolleys $B^{20}$ $B^{20}$. Obviously this same construction could be applied to both axles of the car. The forward trolleys or one set of the trolleys $B^{20}$ $B^{20}$ may be employed to lead current to the three conductors D, D', $D^2$, which lead to the commutator sections of a motor transformer, $D^3$ on the car and from which the current is led to the storage battery $D^4$, also on the car. These trolleys may all of them, however, lead directly to what is known as omnibus conductors lying along the car, and the circuits of the car may then begin with these omnibus conductors. The omnibus conductors are indicated in Fig. 5 as E', $E^2$ $E^3$ and they are connected at each end with one trolley so that each is in circuit when its trolley is in contact with one of the rails B', $B^2$, $B^3$. A box or case, preferably underground, is provided with the three chambers F', $F^2$, $F^3$. In the lower chamber is situated the bared portion $F^4$ of the underground cable $F^5$, which contains a series of conductors. From each of these conductors leads one conductor $F^6$ to the primary coil $F^7$ in the compartment $F^2$. Opposed to this primary coil is the secondary coil $F^8$ in the same compartment.

$F^9$ $F^9$ are pipes by means of which the compartments may be filled with oil, the pipes being then sealed in any desired manner.

The electrical switching mechanism is contained in the compartment $F^3$, and is composed as follows:—G is a solenoid in the circuit G' which leads from the rail B' to the rail $B^3$ and this solenoid has a core $G^2$ to which is secured the cord or chain $G^4$ on the drum $G^5$,

which is fixed on the shaft $G^6$ and is free to rotate through a part of a circle, being drawn in one direction by the action of the magnet G and in the other by the spring $G^7$, secured to the fixed projection $G^8$. And fixed within the box, for example, on the cross bar $G^9$, are the fixed contacts $G^{10}$ $G^{10}$ from which lead the conductors $G^{11}$ $G^{11}$ each to one of the rails $B'$ $B^2$ $B^3$ or to one section of such rails, for as shown these rails are sectional. $G^{12}$ $G^{12}$ are contact blocks on the drum $G^5$ and adapted when the drum is rotated to engage each one of the fixed contacts $G^{10}$ $G^{10}$. All these parts are suitably insulated in any desired manner and from each of these contacts $G^{12}$ $G^{12}$ leads one conductor $G^{13}$, which said conductors terminate each in a secondary converter coil $F^8$.

In Fig. 7 I have shown the arrangement of devices whereby a switch is provided to deliver current from a single transformer to two or more sets of sections of rail. The construction is sufficiently indicated in the diagram Fig. 7 when taken in connection with Fig. 5 and the description thereof. In this case the switch boxes are indicated by the letter H and each contains its own magnet G and switching device like that shown in Figs. 5, 9 and 10, while from the secondary coils $F^8$, three conductors H', $H^2$, $H^3$ pass to the switch box above, and to the switch boxes in both directions.

In Fig. 8 is diagrammatically illustrated a large motor transformer J fed by the three conductors J' $J^2$, $J^3$ leading respectively from the omnibus conductors E', $E^2$, $E^3$ and said motor transformer delivers a direct current to a suitable driving motor on the car (not shown) delivering the same on the main conductors $J^4$, $J^5$.

Referring to Fig. 13 and the associated figures, I have illustrated the construction of a mechanical switch. K is a hanger on the car, carrying the trolleys $B^{20}$ $B^{20}$ $B^{20}$, from which current is led as before to the omnibus conductors on the car or to other parts as may be preferred. These trolleys bear each upon a section of a rail K', $K^2$ $K^3$, which said rail sections are supported on insulation cross pieces, which latter are supported on the walls of the conduit by the cleats $K^{14}$, above the supporting ends $K^5$, $K^5$ of the cross piece $K^{16}$. Each rail is connected by a conductor $K^6$ with contact points $K^7$. On the same cross bar $K^{16}$ are the contact points $K^8$ $K^8$ leading each by a conductor $K^9$ to the secondary coils $F^8$. The switch proper consists of three arched insulated conductors $K^{10}$, $K^{10}$ $K^{10}$ secured together on a pivot $K^{11}$ and adapted to be rotated so as to engage at their extreme ends each one of the contacts $K^8$ and one of the contacts $K^7$ so as when in proper position to bridge said contacts and complete the three circuits through the three arched insulated conductors. The switch compartment may be filled with oil as well as the two lower compartments. Any kind of an electrically controlled or operated device may be associated with the electric switch instead of the solenoid G shown; as for example, the magnet O and armature O', shown in Fig. 3. L is a laterally projecting arm on the carriage which supports the trolleys $B^{20}$ $B^{20}$ $B^{20}$ in the device of Fig. 13, and L' is an arc-shaped piece upwardly curved at its ends and secured on the pivot pin $K^{11}$ with the oppositely arched conductors $K^{10}$. The ends of the arc-shaped piece L' project through the arc-shaped slots $L^2$ $L^2$ on the cross bar $K^{14}$, and are within reach of the finger $L^3$ on the end of the arm L.

The use and operation of my invention are as follows: I have shown and will describe its use and operation in connection with multiphase currents though it will be obvious that many of its features could be employed with other currents and I do not wish therefore to be limited in its application to multiphase currents alone. On the car I would preferably have as indicated omnibus conductors, three if a three phase motor is used. I would provide upon the car a small motor transformer suitably connected with three omnibus conductors and having associated with it a storage battery preferably of a few coils to be charged by a direct current delivered by such transformer. This device could be kept in circuit as required and there would always be a certain amount of energy stored in the storage battery. When therefore the car is stopped or out of operation and it is desired again to start, the switches which are preferably electrically operated, may be operated so as to put the car in circuit and supply current to it by means of the three-phase current delivered from the motor transformer, itself driven from the storage battery. I would also preferably employ upon the car multiphase or three phase motors perhaps associated with an axle of the car as suggested and their windings also should derive current from the omnibus conductors of the car. These omnibus conductors are each and all of them continuously in circuit by the action of the trolley wheels which engage the conductor rails on the surface and are so situated that the distance from center to center between the fore and aft trolleys is substantially the same as the length of the rail section. The car will of course have the usual controlling switches, resistances and the like and preferably suitable clearing brushes on both sides of the trolleys. The sectional rails at the surface or elsewhere from which the trolleys thus take up the current are successively brought into circuit as the car advances by means of the switching mechanisms associated with such rail sections. This is accomplished in the following manner: The underground cable is brought into a fixed box where its conductors are bared and primary coils of a converter connected therewith. The secondary coils are exposed to the primaries and from them lead conductors to contacts within a box above. These contacts have opposed to them other contacts and one of the two sets of contacts

is capable of motion so as to be brought in or out of engagement with the other set. With the three phase current the coils would have three terminals and the contacts would preferably be three in number in each set.

A solenoid or the like is adapted to control the movable set of contacts, for example, in opposition to a spring or the like. These two sets of contacts are normally disengaged, but when the solenoid is energized they are brought into engagement. This solenoid is connected with say two rails one in each of two successive groups of rail sections. Evidently now when these rails are in circuit and are receiving current such solenoid or the like will itself receive current and thus be energized. When energized this solenoid will move the movable contacts and bring them into engagement with the fixed contacts and thus the three sections of any given group of rails will be brought into circuit with the secondary coils of the converter and if these rails are now in circuit by means of the trolleys upon them running with the mechanism on the car the latter will receive current. In other words if the car is approaching a given section or group of sections of rails as soon as the forward trolleys engage this section the rear trolleys being upon the last preceding section it is clear that a circuit will be formed from the front trolley through the solenoid to one of the rear trolleys and since the mechanism on the car is in circuit and receiving current from the rails a portion of that current will immediately flow over the circuit thus completed through the solenoid and the latter will be energized and the switch will be operated and current will be led to the three sections in the group of rails associated with such switch. These three sections therefore will supply current to the driving motor on the car and the same operation will be repeated from group to group as the car advances. This operation will be the same evidently when a direct current motor is used when in this instance it will be the principal motor transformer which is directly brought into the circuit and the current passed through it will be converted into a direct current to flow thence through such direct current motor. It is equally evident that the same operation will go on with regard to any switch box where a series of such switch boxes are employed as shown in Fig. 7. With regard not to the mechanical switch and underground conduit the operation is the same except that the switching is accomplished mechanically and not electrically. In this case the special motor transformer and storage battery may be dispensed with. The mechanical switch is normally open, but when the forwardly projecting prong on the moving car comes in contact with the projecting rod of such switch it moves it bringing the arched conductors shown in Fig. 14 into contact at their ends with the contact blocks $K^7$ $K^8$ so that the secondary coils of the converter are brought into contact with the three rail sections on which the trolleys are running and this condition of things will continue until the car has passed on to the next section which next section in that case will in like manner be brought into circuit. The rear hook or prong on the car will then engage the other end of the rod associated with the switch and move it into the position shown in full lines in Fig. 18 or into its normal position, when the circuits are again broken and the said rail sections are out of circuit.

To summarize, I have illustrated my invention as applied either to underground conduits or surface conductor rails and with mechanical or electrical switches and with a three phase current.

On the car I have illustrated, the use of a three-phase motor converter adapted to give a direct current to a direct current motor to drive the car. And I have also shown on the car a secondary three-phase motor transformer, adapted to charge a storage battery with a direct current said storage battery in turn adapted to supply current to the motor transformer whereby to deliver a three-phase current to the rails and thus energize the electrical switches in cases where no other current can be utilized for that purpose. The motor transformer may be so wound as to run in the same direction, whether used as a generator of multiphase currents, driven by the storage battery, or as a charging generator driven by multiphase currents from the rails. The devices here shown are in part at least readily applicable for the utilization of currents direct, alternating or multiphase, as can be easily seen.

I claim:

1. In an electric railway system the combination of exposed conductor rails arranged in groups of sections and adapted to be brought into circuit with a moving motor with insulated main conductors, a multiphase generator connected with such mains, a series of converters each having primary coils permanently in the main circuit and secondary coils having part circuits terminating at each end in one exposed rail, said part circuits normally open, a device to close the same on the approach of the car, said device including a conductor permanently connecting successive groups of rail sections so as to make a permanent connection between them, and a multiphase motor on the car.

2. In an electric railway system the combination of exposed conductor rails arranged in groups of sections and adapted to be brought into circuit with a moving motor with insulated main conductors, a multiphase generator connected with such mains, a series of converters each having primary coils permanently in the main circuit and secondary coils having part circuits terminating at each end in one exposed rail, said part circuits normally open, a device to close the same on

the approach of the car, and fore and aft trolleys adapted when on different groups of sections to operate said device and furnish thereby current to the motor of the car, and a multiphase motor on the car.

3. In an electric railway system the combination of exposed conductor rails arranged in groups of sections adapted to be brought into circuit with a moving motor with insulated main conductors and a series of converters each having a primary coil permanently in the main circuit and a secondary coil having a part circuit terminating at each end in one exposed rail, said circuit normally open, a device to close the same on the approach of the car and fore and aft trolleys adapted when on different groups of sections to furnish between them current which operates such device associated with one set of trolleys.

4. In an electric railway system the combination of exposed conductor rails arranged in groups of sections and adapted to be brought into circuit with a moving motor with insulated main conductors, a multiphase generator connected with such mains, and a series of converters each having a series of primary coils permanently in the main circuit and a series of secondary coils having part circuits terminating at each end in one exposed rail, said part circuits normally open, a device to close the same on the approach of the car and fore and aft trolleys adapted when on different groups of sections to furnish the current which operates the device associated with one of the sets of trolleys and said devices including each a conductor permanently connecting two successive groups of rail sections, and a multiphase generator to supply current, and a multiphase motor on the car.

5. In an electric railway system the combination of insulated mains with converters whose primary coils are permanently in circuit therewith, exposed sectional conductors arranged in groups with which the motor on the car is adapted to be connected, a local part circuit whose terminals are the rail sections of a given group and a local part circuit whose terminals are the rail sections in successive groups, the first of said local circuits normally broken and containing the converter secondary coil, the latter of said local circuits permanently connecting said successive groups, and means connected with the latter to close the former responsive to a current delivered from the car, and a multiphase generator to supply current, and a multiphase motor on the car.

6. In an electric railway system the combination of insulated mains with converters whose primary coils are permanently in circuit therewith, exposed sectional conductors arranged in groups with which the motor on the car is adapted to be successively connected, local part circuits whose terminals are the rail sections of a given group, which circuits are normally broken and contain the secondary coils of a given converter and a supplemental local circuit whose terminals are sections in successive groups, and means connected with the supplemental circuit to close the other local circuits responsive to the current delivered from the car, and a multiphase generator to supply current, and a multiphase motor on the car.

7. The combination of a movable car with means for leading from an insulated conductor a multiphase current thereto, a multiphase motor transformer on such car, a storage device to receive from such motor transformer and a switch to control connections from the insulated cable to the car, said switch responsive to a current delivered from such storage device.

8. In an electric railway system the combination of exposed conductor rails in groups of sections and adapted to be brought into circuit with a moving motor, with insulated main conductors, connections from such main conductors to the rails of each group of sections, a multiphase generator to supply current to such system and a multiphase motor on the car to be actuated by such current.

9. In an electric railway system the combination of exposed conductor rails in groups of sections and adapted to be brought into circuit with a moving motor, with insulated main conductors connections from such main conductors to the rails of each group of sections, a multiphase generator to supply current to such system and a multiphase motor on the car to be actuated by such current, said connections from the rails to the main conductors normally open with a switch interposed and provided with a series of contacts, said switch controlled from the car.

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