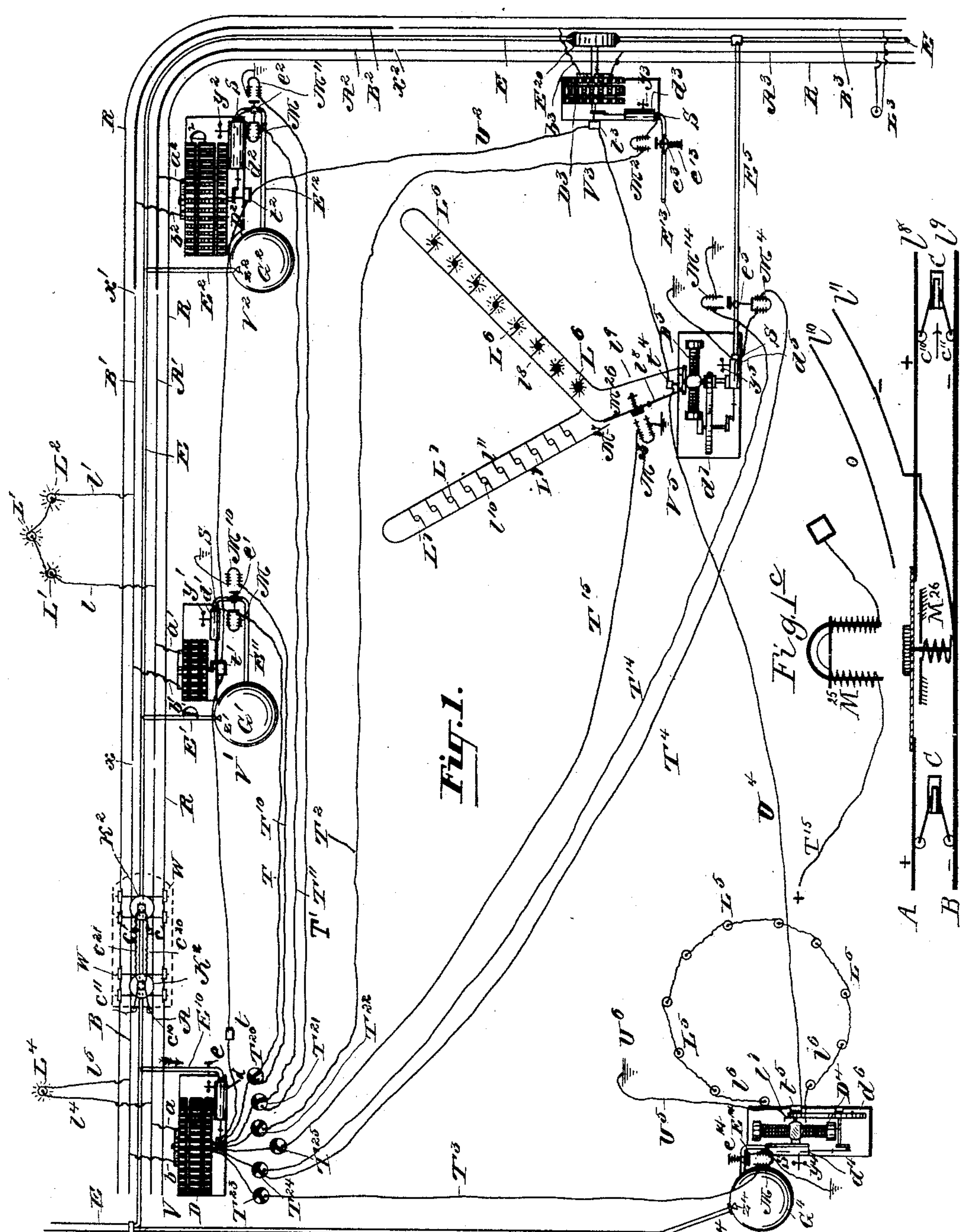
(No Model.) 6 Sheets—Sheet 1.

# I. W. HEYSINGER.

## ELECTRIC RAILWAY, POWER, AND LIGHTING APPLIANCE.

No. 385,413. Patented July 3, 1888.



WITNESSES:

Geo. Dean,
Wm. H. Carson.

INVENTOR.

Isaac W. Heysinger.

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

(No Model.) 6 Sheets—Sheet 2.

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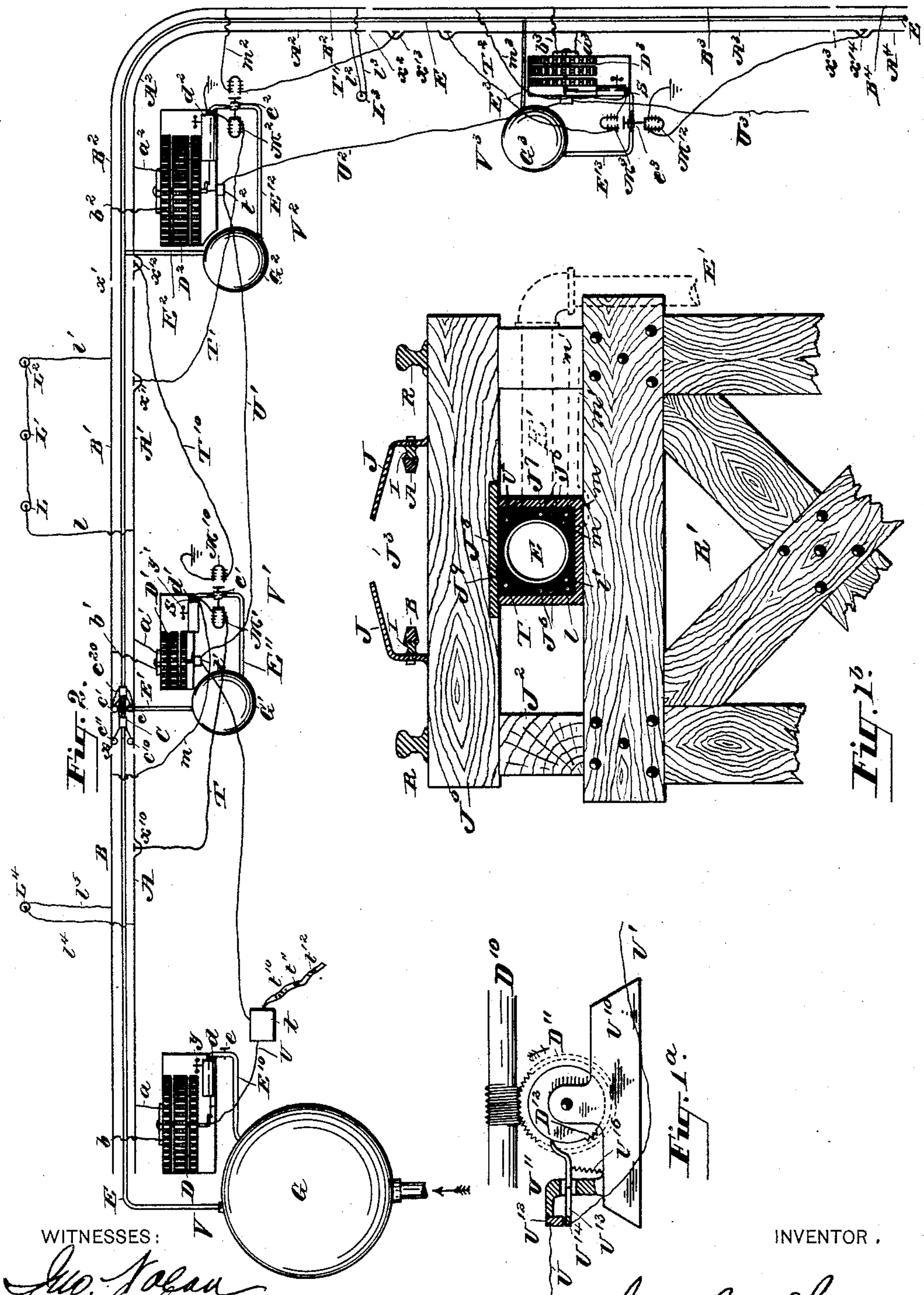


WITNESSES:

Geo. Nolan
Wm. H. Carson.

INVENTOR.

Isaac W. Heysinger.

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

(No Model.) 6 Sheets—Sheet 3.

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## ELECTRIC RAILWAY, POWER, AND LIGHTING APPLIANCE.

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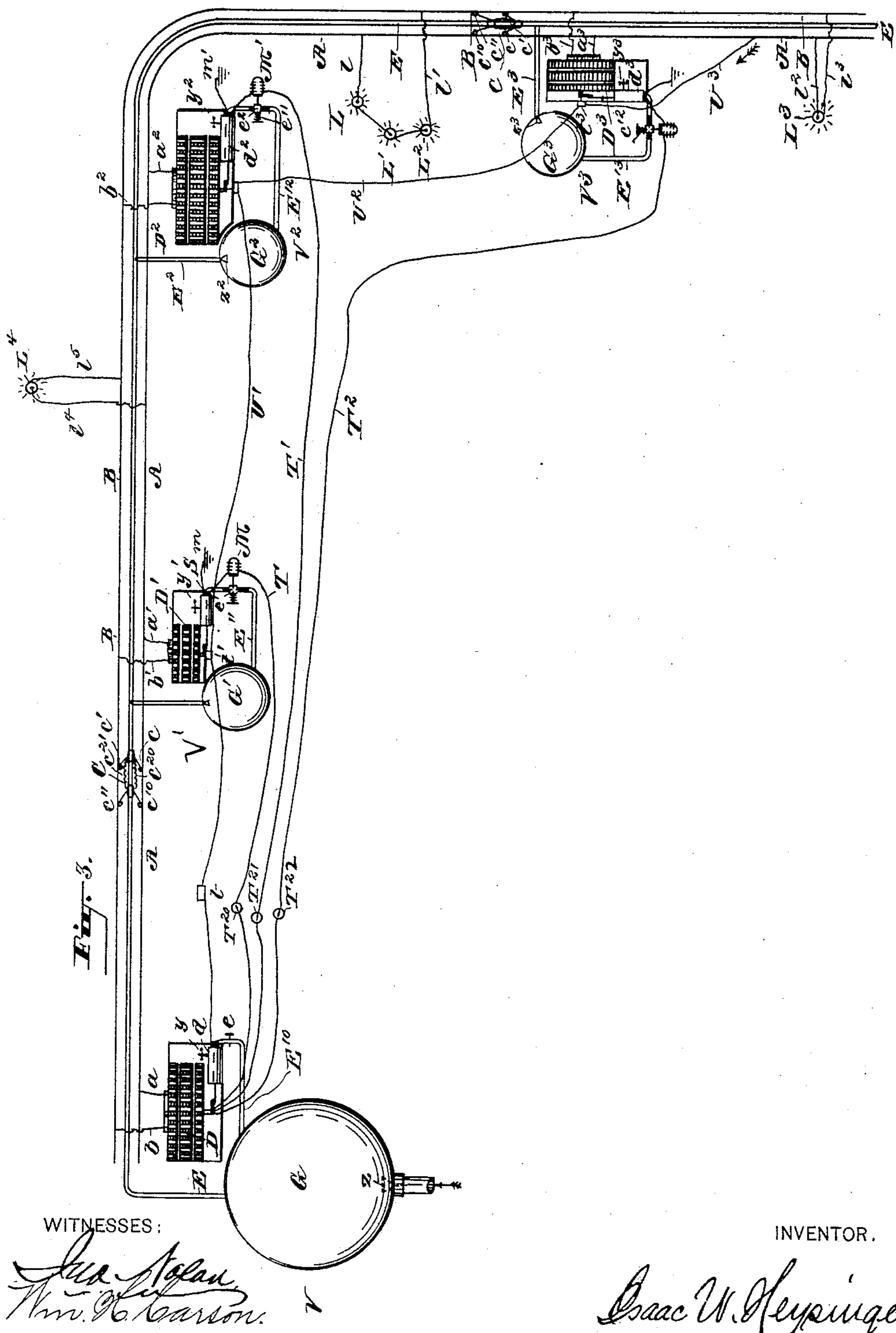

Fig. 3.

WITNESSES:

Geo. Nolan
Wm. H. Carson.

INVENTOR.

Isaac W. Heysinger.

(No Model.) 6 Sheets—Sheet 4.

# I. W. HEYSINGER.

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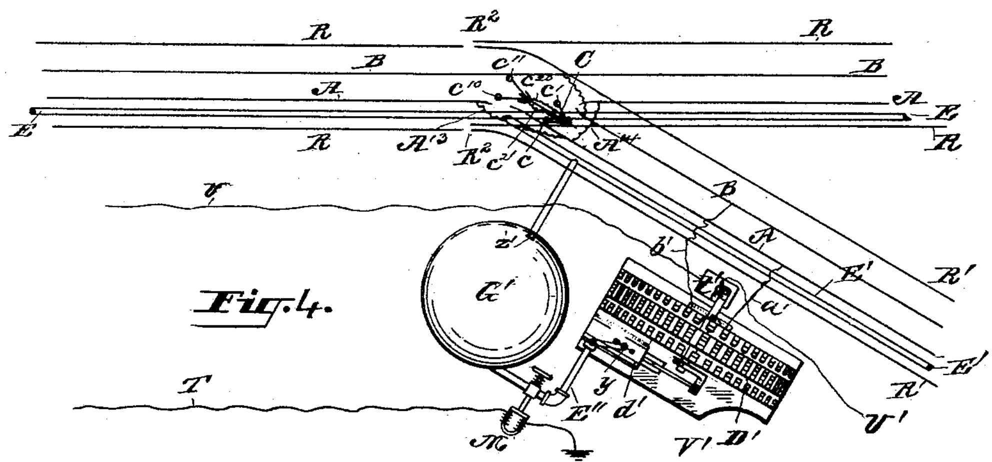

Fig. 4.

WITNESSES:

Jas. F. Nolan.

Wm. H. Carson.

INVENTOR.

Isaac W. Heysinger.

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

(No Model.) 6 Sheets—Sheet 5.

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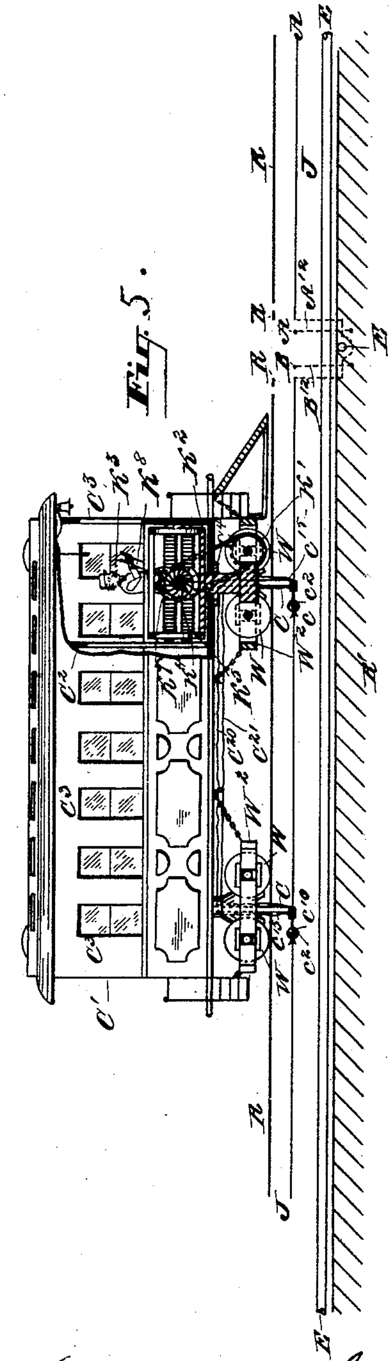

WITNESSES:

Jno. Nolan.
Wm. H. Carson.

INVENTOR.

Isaac W. Heysinger

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

[redacted]

(No Model.) 6 Sheets—Sheet 6.

# I. W. HEYSINGER.

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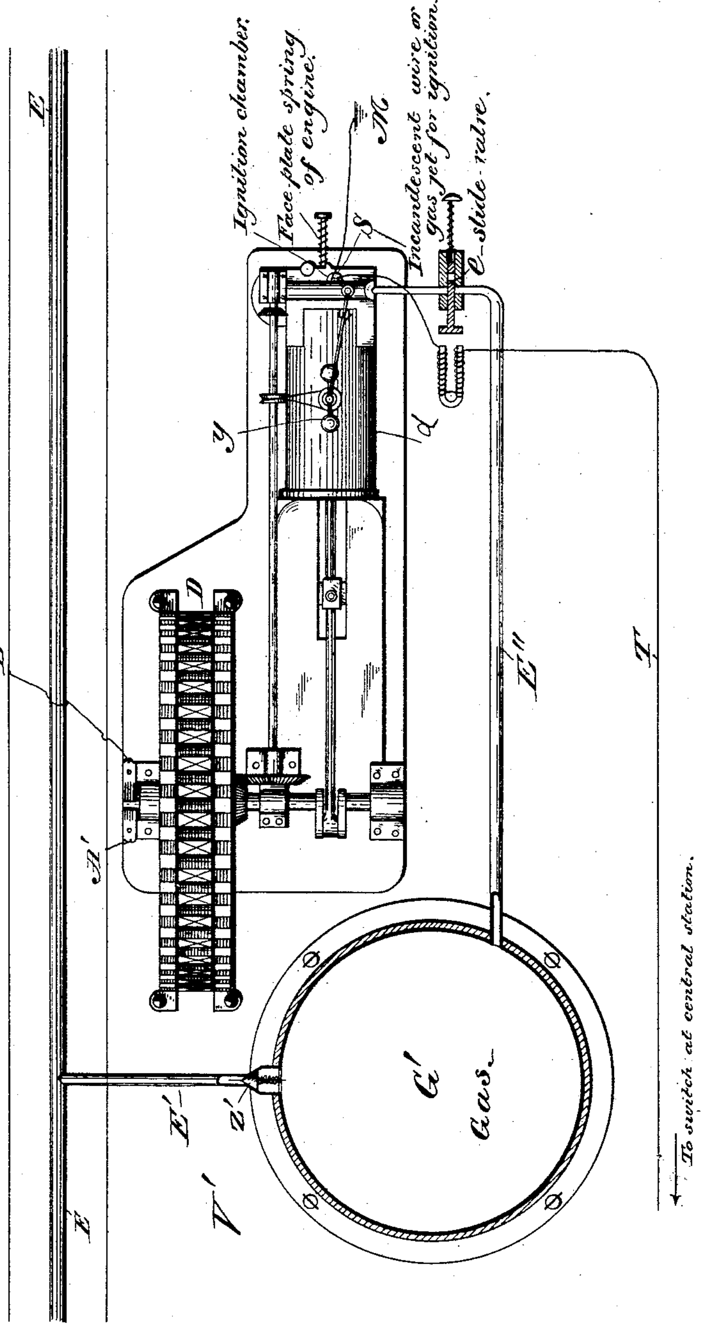


Fig. 6.

WITNESSES:

Geo. Nolan

Joshua Pusey.

INVENTOR.

Isaac W. Heysinger.

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

# UNITED STATES PATENT OFFICE.

ISAAC W. HEYSINGER, OF PHILADELPHIA, PENNSYLVANIA.

## ELECTRIC RAILWAY, POWER, AND LIGHTING APPLIANCE.

SPECIFICATION forming part of Letters Patent No. 385,413, dated July 3, 1888.

Application filed April 21, 1887. Serial No. 235,584. (No model.)

*To all whom it may concern:*

Be it known that I, ISAAC W. HEYSINGER, of Philadelphia, in the county of Philadelphia and State of Pennsylvania, have invented certain new and useful Improvements in Electric Railway, Power, and Lighting Appliances, of which the following is a full, clear, and exact description, reference being had to the drawings accompanying and forming a part of this specification, in which—

Figure 1 is a plan view, greatly shortened and reduced in size, of my invention as applied to an electric railway provided with independent lighting-circuits, in which a common fuel-gas-pipe line is shown with suitable branches, each supplying an independent gas-engine and dynamo-electric machine attached thereto at various points along the line with motive power, and in which the said engines are started or stopped by electric connection with the central station of the system, and in which an automatic recording apparatus at the said central station indicates the operation and movement of each dynamo at any moment and makes a permanent record of the same, the engine $d^2$ and dynamo $D^2$ being larger than the others. Fig. $1^a$ is a view of one of the circuit-breaking devices detached from the dynamo. Fig. $1^b$ is a transverse vertical section of an elevated railway in which my invention is used. Fig. $1^c$ is a view of the sub-circuit supplied by $V^5$ of Fig. 1 applied to a railway instead of an electric-lighting circuit, the same being equally adapted for either purpose or for supplying electric power for other purposes. Fig. 2 is a modification of Fig. 1, in which the dynamos of each section of the railway are successively started as the motor-car advances and stopped after it has passed. Fig. 3 is a plan view, similar to Fig. 1, in which a continuous and unbroken line of electric conductors is employed leading from the central station, each of said conductors having supplied to it at various points along the line reenforcing or independently-generated currents of electro-motive energy, said currents generated by engines and dynamos located at the points of the line where the currents are supplied to the same, so that light-weight conducting-leads will suffice and loss of electro-motive force will be avoided, the said engines and dynamos being controlled by the movements of the dynamo, or the operator thereof, at the central station of the line. Fig. 4 is a plan view of a switch showing the advance of an electric motor-car from the main line to a branch railway in my invention. Fig. 5 is a side elevation, partially cut away, of a motor-car and road-bed of a railway illustrating my invention as applied thereto; and Fig. 6 is an enlarged plan view of one of my sub-stations and its connected parts.

The lettering in all the figures is uniform.

My invention consists in providing an electric supply-service for railway, power, or lighting purposes in which the conducting-leads of said service are connected with a central station and are provided at various points of the said conducting-leads with independent generators of electricity and engines for operating the same located at the said points where said independent generators deliver their currents to the conductors, so as to avoid the necessity of large and costly current-conducting leads extending along the line, with their consequent loss of power, due to internal resistance and waste, the said engines and generating-dynamos of the said service being connected with the said central station or central stations, so that the same may be started, stopped, or controlled by an operator at said central station, and in which the operations of said engines and dynamos are made known at said central station at any or all times, and also in providing a service of gas-pipe supplying fuel-gas to the independent engines along the line, located at points more and more distant from said central station, said gas-pipe being provided with branch pipes and gas holders or reservoirs along the line for the supply of said independent engines, the said gas being turned on or cut off from any or all of said engines and ignited or extinguished to set into operation or stop the motion of the same and at the same time control the generating-dynamos worked by said engines, each of said dynamos supplying a contiguous portion of the line of conducting-leads with electricity by electric connection with said central station, at the will of the engineer or by the motion of a motor-car along a railway provided with the above-described appliances; and also in providing such electric service, having independent dynamos operating at distant points of the line, with a recording apparatus, by means of which the motion and speed of each dynamo of the service will be automatically transmitted to the central station and recorded thereat for present knowledge or future reference; and also to provide an electric railway with longitudinally-extended conducting-leads along the said line of railway, said leads divided into insulated longitudinal sections, each of which is provided contiguous to said section with an independent generating-dynamo, operated by an independent engine or other source of power, generating the electricity for each section of the railway immediately at or contiguous to such section, so that the entire line is supplied with electro-motive force from a series of independent generating stations and dynamos larger or smaller, as the grades or traffic of each section may require, and located at those parts of the line where the said electro-motive force is to be used, the motor-car traversing the line from one section to another, and at each section using the independent supply generated and delivered to said section by the dynamo contiguous thereto; and also in providing such engines and dynamos, located at each longitudinally-insulated section of the line, with electrically-operated valves to control the same from a central station or from sections of the line beyond the section to be supplied with electro-motive energy, so that the advance of an electric motor-car will successively set into operation the engines and dynamos of one or more sections in advance and cut out one or more sections in the rear as the car moves along the trackway; and also in providing a continuous series of electric conducting-leads, partially charged with electricity from a central station, with re-enforcing supplies delivered to said leads at various and more and more distant parts of the line to compensate for enery dissipated by defective insulation, internal resistance, or energy drawn off for service elsewhere, and in so connecting these independent sources of supply with the central station that the operations of each dynamo of the line may be known and controlled by an operator at said central station, or by subordinate operators at the various sub-stations as directed from said central station, the various sources of supply along the line being located at and generating electricity immediately contiguous to the points where said supplies are to be used; and also in the combination of an electric supply service extending from a central station, with a fuel-gas service extending along the same, said electric service having a series of generating-dynamos at different points along the line to supply electro-motive energy, and said fuel-gas service having a line of gas-pipe with branches supplying fuel to operate gas-engines in a similar series, each gas-engine having a generating-dynamo coupled thereto in pairs, the gas-engine driving the dynamo and the dynamo generating and supplying electricity to one part of the electric service, either for supplying light or power or electric energy for other purposes.

This part of my invention also relates to the specific construction and combination of the various parts of the same, as will be more fully hereinafter explained, together with the construction and operation of the electro-magnetic valves, current-breaking and recording-telegraph apparatus, telephone or other connections, and other matters of detail essential to the most efficient application of my invention, but not always required in use.

Referring to the drawings, in Fig. 1 is shown a central station, V, provided with a gas-engine, *d*, driven by a supply of fuel-gas supplied by a branch pipe, $E^{10}$, extending from the main supply-pipe E.

I use any of the forms of gas-engines in public use or which may be adapted to the purpose; but, for illustration, in Fig. 6 I show a fuel-gas engine substantially similar to that described and illustrated in "Appleton's Cyclopedia of Applied Mechanics," edition of 1880, pages 633 and 634, to which I refer for a more specific description, to the crank-shaft of which the rotating armatures of a large dynamo-electric machine are attached and operated thereby. The conversion of the energy derived from combustion of fuel-gas, as described herein and supplied in the manner shown into electrical energy at various points along the line or lines of my electric supply service and supplying the said electricity to the electric conductors or leads at such points, is one of the principal objects of my invention, whereby the waste due to imperfect insulation from the transmission of powerful electric currents along extended lines and the necessity of excessively large conductors is avoided, the fuel-gas generated at distant points being readily carried along the line without any waste whatever and at very small expense for plant, the gas thus transmitted taking the place of the continuous and easily-dissipated electric current, the former being converted into the latter immediately at or near to the place where the electric current is to be utilized in doing work. Hence I use any form of engine for converting the energy of combustion tion of the said gas into electric energy which may best serve the purpose in view or be most convenient for the special objects to be accomplished, whether mechanical, chemical, thermal, or other equivalent, using the engine specifically shown in the figures to illustrate my invention, but not rigidly confining myself thereto.

This gas-engine *d* drives the dynamo-electric machine D, which supplies electricity through the conductors *a* and *b* to the positive and negative leads A and B of a main circuit. These leads A B extend along the line of railway R R and supply electricity to a motor-car, C, traveling along the trackway of the same, having a motor-dynamo connected with the leads A and B by current-gathering devices $c\ c'\ c^{10}\ c^{11}$, as shown. The leads A B terminate at $x$.

V′, Figs. 1, 2, 3, 6, is a sub-station, which may be a half-dozen or dozen miles down the line, and is provided with a gas-reservoir, G′, into which fuel-gas flows from the pipe E through the branch E′, and is preferably prevented from flowing back by the check-valve $z'$ should the pressure in E become too greatly diminished.

$E^{11}$ is a branch leading from the reservoir G to the gas-engine $d'$, which supplies power to the dynamo-electric machine D′, and which, in turn, through the wires $a'\ b'$, charges with electricity the leads A′ B′, which form a continuation of the leads A B, but are insulated at $x$ to make an independent circuit. The leads A′ B′ extend to $x'$, where, in turn, they terminate. At $V^2$, another distance of a dozen miles, more or less, down the line, is a precisely similar gas-holder, $G^2$, connecting pipe $E^2$, valve $z^2$, supply-pipe $E^{12}$, gas-engine $d^2$, and operating-dynamo $D^2$, said engine $d^2$ and dynamo $D^2$ being larger in size than the others, which, through the wires $a^2\ b^2$, charge the leads $A^2\ B^2$, which form a continuation of A′ B′, but from which they are insulated at $x'$.

$V^3$ is another sub-station along the line, having the same appliances as V′ and $V^2$, and supplying the leads $A^3\ B^3$, insulated from $A^2\ B^2$ at $x^2$, and so on as far as the line extends.

It will be observed that the gas-supplying pipe E extends along the entire line; but this is not necessary in all cases, as the gas is generated at the most convenient points along the line, and may have one or more sources of supply. Reservoirs are also shown at each substation; but these may not be necessary in all cases, where equal currents can be otherwise secured. Upon each gas-engine is shown a governor, $y\ y'\ y^2\ y^3$, &c., the function of which is to cut off the gas from the cylinder of the engine to a greater or less degree through a throttle or other valve, so as to insure even and steady running of the engine and a regular supply of electricity to the leads from the generator operated by said engine. The stations V, V′, and $V^3$ have electric lights, which may be arc or incandescent, supplied from the leads of the railway service from the dynamos of the sections to which they are attached. $L^4$ is shown lighted, the current being on, and $L^3$ is shown unlighted, the current being cut off, as will be further explained.

L, L′, and $L^2$ are lamps connected in series, the current passing in through $l$ from one lamp to another, and finally out by $l'$ and back to the generator D′ at the sub-station V′. The gas-pipe E branches at the station V, and one branch, $E^4$, passes down to the sub-station $V^4$, which is shown in Fig. 1 as a lighting-station only, though equally adapted for use for railway purposes, as shown in Fig. $1^c$, having for clearness of illustration no railway attached. The reservoir $G^4$ is protected by the check-valve $z^4$, and passes a current of fuel-gas through the pipe $E^{14}$ to the gas-engine $d^4$, which actuates the dynamo $D^4$ and supplies electric energy to the series of lamps $L^5\ L^5\ L^5$. The sub-station $V^5$ derives its fuel-gas supply from the pipe E through the branch $E^5$, which transmits the same, without the intervention of a reservoir, to the gas-engine $d^5$, which drives the generating-dynamo $D^5$, and supplies electricity to the circuit $l^3\ l^9$, and lights the lamps $L^6\ L^6\ L^6$ of said circuit, which are shown as arranged parallel, and not in series. The lamps of $V^4$ and $V^5$ may be either arc or incandescent, and placed for street, factory, or house lighting.

In Fig. 1 the lamps of $V^5$ are shown lighted and of $V^4$ unlighted. It will be seen that in the figure all the sub-stations draw their fuel-gas from the same plant; but this need not be so in all cases, nor need gaseous fuel be used, as other sources of power may be employed; but I prefer to use gas as being very cheaply made, easily transported, without expense after first cost of plant has been incurred, and especially adapted for use where natural gas is accessible. Fuel-gas composed of the light hydrocarbons and hydrogen, with or without an admixture of carbonic oxide, is now very cheaply produced in unlimited quantity and with an inexpensive plant, and can be easily driven through pipes for long distances.

The cost of a four-inch iron pipe for use with my system need not be more than twelve hundred dollars per mile, which is trifling compared with the cost of rails and other appliances of an ordinary railroad, or with heavy copper conducting-leads, expensive to make and unite with perfect joints at their ends, without buckling from change of temperature, when of a diameter of two, three, or more inches which would be required for a large working-plant, and the loss of electricity upon long lines charged from a central station, so that the advantages of my present invention will be apparent.

It is also known that gas burned for illumination greatly preponderates in the heat-rays, which yield no light over the light giving rays, while the reverse is the case with electric lights, so that a very great economy is obtained by burning common illuminating-gas to drive an engine, which in turn operates an electric generator to furnish the light, and much more when a low-priced fuel-gas is used, not costing more than twenty-five cents per thousand feet, and in many cases much less. Natural gas can be delivered sixty miles in pipes at a cost of not more than five or six cents per thousand cubic feet.

To drive the gas through the pipes, I use rotary blowers or other mechanical means, when the pressure is not sufficient to cause it to flow by its own pressure, and I use such regulating devices at the different reservoirs of the line as will prevent excessive pressure therein, such as cut-off valves, like $z$, controlled by springs or other well-known means in use for like purposes—such as gas-regulators. When the blowing apparatus is insufficient at one part of the line to drive the gas through the pipe in sufficient volume, I use supplemental blowers $E^{20}$ at various sub-stations, driven by the engines thereat, so that the current of gas is passed along at any pressure and in any quantity desired.

The engines and dynamos at the different sub-stations may be operated independently by persons in charge of said stations by means of a time-table or a telegraph or telephone connection with each of said sub-stations from the central station of the line; but I prefer to use the mechanism shown in Fig. 1, which is under control of a single mind and hand, and which operates all the engines of the line from a single station thereof. As shown in Fig. 1, from the central station, V, there radiate lines of telegraph-wire to various parts of the line, communicating with each of the sub-stations. These wires may be charged for use by a battery; but I prefer connecting them with the dynamo D, which thus supplies electricity to all the wires of the system when said dynamo is in operation. The hand-cock *e* turns on the gas from the supply-pipe $E^{10}$ to the cylinder of the gas-engine *d*, which being ignited in said cylinder, as in gas-engines generally, the engine is set in motion and by its piston-rod and crank-connection rotates the large dynamo-electric generator attached to the crank of the engine, provided with wire bobbins rotating against the faces of electro-magnets fixed around the circumference in the manner well known in practice. Of course any other form of dynamo may be used, and in Fig. 1, at $V^4$ and $V^5$, other kinds are shown in use. When the engine *d* is started and the valve or cock *e* remains open, the governor *y*, driven by a belt from the crank-shaft through a bell-crank connection, operates a throttle in the gas-supply pipe $E^{10}$ to keep the engine at a regular and uniform speed of rotation, consuming more gas as the pull of the dynamo becomes greater and less as the resistance diminishes.

For the main circuit of my dynamos I prefer to use the shunt system, which reacts upon the dynamo to vary the power according to the demands of the service, and I couple my dynamos so that polarities shall not be reversed by crowding the excessive current of one dynamo upon the diminished current of another in the same circuit, when I use more than one dynamo in a single circuit; but ordinarily I provide an independent closed circuit for each individual dynamo, increasing the size and power of the engine and generator according to the length, resistance, and other requirements of each sub-circuit of the system. The dynamo D being now in operation, the leads A and B and the telegraph-wires leading to *t*, $T^{20}$, $T^{23}$, &c., are all charged. $T^{20}$ $T^{21}$ $T^{22}$ $T^{23}$ $T^{24}$ are circuit-changing keys, having a connection at the side nearest the dynamo with wires proceeding therefrom, and at the outer side with a single wire, $T^2$ $T^3$ $T^{15}$, or with one or the other of a pair of wires, T $T^{10}$ $T^4$ $T^{14}$, and so constructed that any wire may be thrown into or out of circuit. The circuit-changers or switches $T^{20}$ $T^{24}$, &c., may be of any form desired, and are operated by a push-button or lever. The wires are sufficiently large to carry a current to operate electro-magnets controlling valves for the engines of the line, or to operate actuating mechanism for such valves. One of these wires, $T^2$ $T^3$, or one pair of wires, T $T^{10}$ $T'$ $T^{11}$, extends to each sub station of the line. In the case of single wires they terminate in the coils of an electro-magnet extending laterally from the gas-supply pipe $E^{13}$ or $E^{14}$ of the engines $d^3$ $d^4$, and opposite the poles of said electro-magnet is an armature of soft iron supporting a transversely-slotted stem-valve which slides through the gas-pipe and turns on or turns off the gas from the engine. To the farther end of this sliding stem-valve, projecting from the side of the pipe, is a cross-head, which supports the pressure of a coiled spring surrounding the stem $e^{13}$ or $e^{14}$ and abutting against the side of the pipe. When the switch $T^{22}$ or $T^{23}$ is turned, as shown in Fig. 1, the current of electricity will be cut off from the wire $T^2$ or $T^3$, and the coiled spring $e^{13}$ or $e^{14}$ will hold the sliding valve $e^3$ or $e^4$ in such position that the vent is closed; but if the switch be turned to make contact with the wire a current will pass along the same through the coils of the electro-magnet, which will attract its armature and draw the stem-valve through its transverse channel in the gas-pipe, bringing its slot into apposition with the bore of the pipe, and the gas will flow to the engine, forced forward by the pressure of the holder, when one is used, as at $C^4$, but if none be used, as at $V^3$, then by the pressure in the supply-pipe. The wire passes on from the coils of the electro-magnet to enter the combustion-chamber of the gas-engine, where it terminates in a small platinum wire, S, which by its resistance becomes intensely heated and ignites the mixture of air and gas, which by its expansion drives the engine. So long as the current is on the wire the armature will be drawn up to the electro-magnet and the platinum wire be incandescent; but when the current is turned off by the switch the spring will draw back the armature and close the vent, thus cutting off the gas, stopping the engine and its dynamo, and cooling the platinum wire. Instead of the latter a spark may be used, and other means of ignition may be employed. After passing through the platinum wire the current may be grounded or returned by a negative wire. $T^{20}$, $T^{21}$, and $T^{24}$ only differ from the others in that a pair of wires is used to carry the current alternately, and that two opposite electro-magnets are employed having the gas-feed pipe between said armatures, which are attached to the opposite ends of the stem-valves $e'$ $e^2$ $e^5$, so that the current on one wire will attract one armature and open the valve and on the other wire will attract the opposite armature and close the same.

For certain purposes, where a neutral state is maintained between turning the current on one wire and turning it on the other, as in the passage of a motor-car over a part of the road not in connection with either, but in which the engine is to continue to run, I use double wires, one connected with a section of road in rear and the other with a section of road in advance, so that the approach of a train will prepare the section ahead, and its passage onto a new section will stop the dynamo and engine in its rear. The attachments above described are applied to all the sub-stations of the system, and an inspection of Fig. 1 will show that the current is on V, V′, $V^2$, and $V^5$, but not on $V^3$ or $V^4$. It is often necessary to have the lamps of one part of a circuit lighted or extinguished before the others, and this I accomplish by the wire $T^{15}$. The switch $T^{25}$ turns the current on or off the wire $T^{15}$, which terminates in the coils of an electro-magnet, $M^{25}$, which has a soft-iron armature attached to a hinged or sliding piece connected at one end with the circuit and at the other detachable therefrom. A coiled spring, $M^{26}$, holds the contact-piece, ordinarily, so as to cut out the circuit of lamps $L^7$ or of the electric railway $l^{10}$ $l^{11}$, Fig. $1^c$. When the switch $T^{25}$ is turned as shown in Fig. 1, it will be seen that the spring $M^{26}$ holds the contact-piece so as to close the circuit with the lamps $L^6$, but cut out $L^7$ or $l^{10}$ $l^{11}$ of the railway, Fig. $1^c$. The switch $T^{25}$, being turned, sends a current through $T^{15}$, the magnet $M^{25}$ is polarized, the armature attracted, and contact is made with the circuit $l^{10}$ $l^{11}$, and the lamps $L^7$ are lighted, or the current in Fig. $1^c$ sent into the conductors $l^{10}$ $l^{11}$ of a diverging line of railway. With this explanation other applications will be obvious.

In Fig. 1 the lamps of $V^4$ are arc lights, arranged in series, and of $V^5$ incandescent lamps parallel. The sub-stations may be at one end of each circuit, or midway, as shown in the circuit of $V^3$, and for reduction in size of leads from shortened lengths this arrangement is preferable, especially on railway-lines. I do not, also, always supply a single circuit from one dynamo, but sometimes place the sub-stations at the junctions of insulated sections and divide these insulated sections, if desired, into smaller sections, insulated longitudinally from each other, and shift the current from one to the other, as shown at $V^5$, Fig. 1.

In this case I use a single dynamo and gas-engine for several of such sub-sections, connected as described, and when it is desired to use the electricity thus generated immediately at such stations as to supply storage or secondary batteries, or for other purposes, I do not, as shown at $V^4$ and $V^5$, Fig. 1, use the continuous leads A′ B′, &c., but deliver my electricity into such secondary batteries or use it for lighting or other purposes, as desired. While all the sub-stations of the system are thus controlled from the central station, it is desirable, for perfect working of all the distant parts, to know precisely how all the dynamos are operating at any moment, and I accomplish this in the following manner: From the extreme sub-station to the central station is extended a telegraph-wire tapping all the intermediate stations; or separate wires extending from the central station to any of the sub-stations may be used, if desired.

In Fig. 1 the line U, U′, $U^2$, $U^3$, $U^4$, and $U^5$ is composed of wires extending from one sub-station to the other, and so on back to the central station, the wire being charged from a battery, or preferably from the dynamo D. The ends of these wires U U′, &c., are in contact except when broken by the revolution of the shafts of the engines at each sub-station; and near the central station, upon the wire, is a Morse recording-telegraph instrument, with clock-work or other means of moving a paper strip or ribbon under the indenting-point of the armature of the electro-magnet, which makes the record thereupon; but in this instrument the record is made by the pressure of the retracting-spring of the armature when the circuit is broken instead of when closed.

In Fig. $1^a$ is shown the circuit-breaking devices which I use at each sub-station. $D^{10}$ is a shaft preferably rotated by the crank-shaft of the engine or dynamo D′ or $D^2$, and has a worm-gear which actuates a spur-wheel, $D^{11}$, as shown, the latter rotating in the direction of the arrow. Upon the face of $D^{11}$ is a ring with one, two, or more teeth, $D^{12}$, of any shape desired. Against this ring and teeth $D^{12}$ engages the point of a lever, $U^{13}$, carrying at its rear end a contact-piece, $U^{14}$, to which is attached the wire U′, extending forward to the next sub-station. The contact-piece $U^{14}$ rests normally against the conducting-block $U^{12}$, to which is attached the wire U, extending back to the telegraph-instrument $t$ and the central station. The lever $U^{13}$ is held in place by the traction-spring $U^{16}$. As the dynamo D′ rotates upon the shaft of $d'$, and the spur-wheel $D^{11}$ revolves at each revolution, the teeth $U^{15}$ will engage successively with the end of the lever $U^{13}$, and the circuit will be broken three times in rapid succession, but will remain closed during the remainder of the revolution of $D^{11}$. At the same time the recording-instrument $t$ will make three indentations in the paper strip and three audible sounds, and then will travel silently for a time.

If an apparatus like $U^{10}$ be used on the other dynamos in the circuit, but having the teeth $U^{15}$ different in number or differently arranged, then the breaks of the circuit will be all recorded upon the same paper strip in succession, and each individual dynamo will make its own distinguishing mark and sound, and the rate of each engine's rotation will be known at any moment. Of course there will be a likelihood, if many dynamos are in the same circuit, of overlapping of the records; but as the intervals are very large compared with the moment required for the record of each, the spaces usually being a minute apart (more or less) for each station, the interference will not be much, and with a little practice they can be read even if somewhat overlapped occasionally.

Of course a different recording-instrument may be used to accomplish the same object, and indeed a telegraph or telephone may suffice; but that requires the presence of an operator at each sub-station at all times, while with such apparatus as I describe, the track-walker who may have charge of that part of the line can pursue his other occupation without interference if upon a railway, or the oiler and lamp-inspector of a lighting service may be equally employed elsewhere. The paper strip is shown in Fig. 2 partially unrolled with the distinguishing records $t^{10}$ $t^{11}$ $t^{12}$ of three dynamos. Where the sub-stations are very numerous, two or more independent wires and two or more recording-instruments may be employed for the same system.

In Fig. $1^b$ an elevated railway embodying my invention is shown in cross section.

$J^5$ are the sleepers or cross-ties which support the rails R R, and beneath which cross-ties extends the gas-pipe E, which is shown embedded in a wooden trough, $J^7$, filled with pitch, $J^9$, in which are carried the wires $l$ $l'$, for electric lighting, $m$ $m'$ T $T^{10}$, for opening the valves, as shown in Fig. 2, $T^{20}$, as shown in Fig. 1, and the record-wires U of Figs. 1, 2, and 3, and certain telephone or telegraph wires $J^6$ $J^6$, for convenience, which the conduit or trough $J^7$ affords. The dotted outline E' shows a branch pipe carrying gas from the main pipe E to a sub-station, and $m'$ $m'$ (shown in dotted lines) are branch wires to the same.

$J^8$ is a lid by which access is had between the cross-ties $J^5$ to the trough $J^7$ and its contained pipes and wires.

A and B are the current-conducting leads against which the current-gathering devices of a motor-car upon the rails R R move, and from which their electro-motive energy is derived. These leads A B are supplied from the central station, and the pipe E' furnishes the fuel-gas to drive the supplying-engines for the next succeeding section.

$J^3$ is the longitudinal slot through which the current-gathering bars of the motor-car reach the leads A B, and J J are protecting hoods or covers over the same, forming a sort of conduit along the roadway. Wires for electric lighting are drawn off from A and returned to B at any point upon the line or at any sub-station thereof, and I also light my moving cars with electricity in the same manner. R' shows the substructure of the same.

In Fig. 2 the system as shown in Fig. 1 is slightly modified to suit special requirements in railways, should such be required. The sub-stations, engines, dynamos, and recording apparatus are the same, the modifications relating to the introduction of appliances whereby a moving motor-car will set in operation the engine and dynamo at the sub-station in advance and cut out the one in rear as it advances, whereby greater economy is secured, as no consumption of fuel or wear of machinery is incurred, except upon the sections immediately in use. The wires shown in Fig. 1 extended from the central station, V, to the electro-magnets at each engine enable the operator at said central station to control these engines therefrom whenever desired. The engine of the central station, $d$, and its dynamo D are controlled by the hand-cock $e$, as already described.

The sub-stations V' $V^2$ $V^3$ are operated as follows: Upon the lead A, charged by the dynamo D, is a slight deflection, $x^{10}$, in which is placed the terminal contact-piece of the wire T, Fig. 2, so that the current-gatherer $c$ at one end of the traveling car C will come in contact with it, while the other current-gatherer, $c^{10}$, on the same side of the car, is in contact with the lead A. A current will pass through the wire T, coils of electro-magnet M', platinum wire or sparking device S, and back through $m$ to the negative lead B, and the engine $d'$ will be set in motion. In this case I prefer to use to ignite the gas a gas-jet from $E^{11}$ in the combustion-chamber of the engine $d'$. By the time the car C has passed from $x^{10}$ to $x$, which is the commencement of the insulated sectional leads A' B', the dynamo D' will be running at full speed. The car passes along A' B', the motor actuated by the electro-motive energy transmitted thereby. When the said car has passed over the interspsace $x'$ and onto the leads $A^2$ $B^2$, so that the current of D' is no longer required, a similar deflection of $A^2$ and insertion of contact-piece of the wire $T^{10}$, in contact with the current-gatherer of $c$, will send back a current through $T^{10}$ to the electro-magnet $M^{10}$, causing it to attract its armature and close the valve of $E^{11}$, thus stopping the engine; but before reaching $x'$ the car C will have encountered, through its current-gatherer $c$, the terminal contact-piece of T' at the deflection $x^{11}$, and a current sent forward over the wire T' will cause the electro-magnet $M^2$ to attract its armature, and so open the gas-valve of $E^{12}$. As there are no springs on the electro-magnets or their armatures, the slide-valve will remain wherever placed until drawn in an opposite direction by an electric current passing through the coils of the opposite magnet. It will now be seen that the advancing car, as it were, prepares its own way and uses no power except what is required at the part of the road where the train may chance to be, and also that the source of power of each car or train is independent of all others upon the line, the sections being permanently insulated from each other. When cars are required to run alternately in opposite directions it is a simple matter to duplicate the feed-pipes $E^{11}$ $E^{12}$ $E^{13}$ and provide each with a different set of electro-magnets and valves operated through wires connected with the sections in a reverse way to that shown and described. In this case the contacts of the wires T $T^{10}$, &c., would be set a little higher or lower than the contacts of the reverse set, so that the reversal of the car or a lever thereupon will throw in one or the other set, as is well known in signaling devices of various kinds. As the reverse wires are precisely similar, to avoid complication in the drawings they are omitted from the figures. While the signal, recording, and switching wires are shown in the figures outside the leads, in practice I carry them alongside the leads of the line, and preferably inclosed in a trough with the gas-pipe E, as shown in Fig. 1[b], or alongside the same. The gas pipes and holders of Fig. 2 are the same as those shown in Fig. 1, and blowers $E^{20}$, Fig. 3, reservoirs $G'$ $G^2$ $G^3$, or the pressure of the gas in the pipes is used to insure the flow of the same, as may be preferred, and in certain cases I dispense with gas and use water power or steam power to drive my dynamos, as may, for special purposes, be preferred; but I prefer to use the mechanism shown for the reasons herein stated.

In Fig. 3 I show another modification, in certain respects, of Fig. 1. As shown in Fig. 3, the electric conducting-leads A B are continuous along the line, not being divided into insulated longitudinal sections, as in Figs. 1 and 2. The sub stations $V'$ $V^2$ $V^3$ are similar to those shown in the other figures, the gas supplying main E having branch pipes to feed the gas-engines, which drive the dynamos coupled thereto, just as in Figs. 1 and 2. The recording apparatus U $U'$ $U^2$ $t$ is also similar. The object of using these separately-driven dynamos along the line may be illustrated as follows: If at the central station, V, the dynamo D supply to the leads A B, when said leads are in circuit, a quantity of electricity, represented by, say, two hundred horse-power, and the leads are, say, two inches in sectional diameter, owing to the internal resistance of the conductors and the dissipation of energy incident to long leads, the available electricity at, say, twenty miles from V will have run down to one hundred horse-power, the leads from V to $V'$ gradually growing weaker, the supply at V remaining the same. If, now, at $V'$ a similar charge of two hundred horse-power be introduced, it will flow backward toward V, banking up the current, so to speak, and making a center of fluxion of the current, or balancing-point, between $V'$ and V, varying as a moving motor-car, deriving its electro-motive energy from A, passes from V to $V'$, and so on for the other sub-stations of the line. The leads will thus be supplied at suitable intervals with a re-enforcement of current precisely as a tube, flowing with water under pressure, and which gradually diminishes in current from friction and resistance, would act if supplied with re-enforcing currents along the line derived from outside sources, or as the rotary blowers $E^{20}$, which I apply to my gas-pipe at various points, as above described, to speed up the retarded current of gas in the main E. The size of the leads A B, thus re-enforced, may be very largely diminished, the length being relatively shortened for each supply-current, and an equalized potential be supplied to all parts of the line. To start the different gas-engines or sources of power along the line, I use the wires T $T'$ $T^2$, extending from the central station, V, to the different sub-stations $V'$ $V^2$ $V^3$, and connected thereat with the coils of electro-magnets M $M'$ $M^2$, as in the other figures, 1 and 9, and I provide the wires T $T'$ $T^2$ with keys $T^{20}$ $T^{21}$ $T^{22}$, as hereinabove described.

I also prefer to use a burning gas jet in the combustion-chamber of each engine to light the gas supplied thereto, and I use this feature, when preferred, in the forms shown in Figs. 1, 2, and 9. When not in use, the wires T $T'$ $T^2$ may be utilized for other purposes. The recording apparatus U $U'$ $t$ is also shown in Fig. 3. As the dynamos D, $D'$, $D^2$, and $D^3$ are all upon the same circuit in Fig. 3, they must be so connected with the leads A B that the current of one dynamo, when in excess, may not reverse one or more of the adjacent dynamos, which may be done by means well known, though the distances apart of these dynamos will greatly diminish the available current from the others by resistance, so that no such danger will be incurred as from dynamos upon the same circuit and near each other. For certain purposes the construction shown in Fig. 3 may be especially adapted; but I prefer, ordinarily, the sectional system shown in Figs. 1 and 2.

I also vary the construction to suit various requirements without departing from the principles of my invention. In Figs. 2 and 3 I do not show the rails of my electric railway, for the sake of simplicity in the drawings; but they are applicable there as well as in Figs. 1 and 1[b].

In Fig. 4 my system is shown as used for switches where it is necessary for trains to pass each other at a turn-out, or to be deflected to a siding or to a diverging railway. R R show the trackway of an electric railway-line having a switch at $R^2$, and $R'$ $R'$ represent the diverging line. The leads A B supply electricity to the car C, having a pair of current-gathering devices attached to the said car and connected by a sliding contact with A B to convey the current from the leads to the motor.

$D'$ represents a dynamo driven by a gas-engine, $d'$, deriving its power from the combustion of fuel-gas supplied from the gas-pipe E to the holder $G'$, and from thence through the pipe $E^{11}$ to the engine $d'$. The electro magnet M turns on or off the gas, as described hereinabove in connection with Figs. 1, 2, and 3. The electro-motive energy is supplied to the leads A B from the brushes of the armature through the short conductors $a'$ $b'$. T operates the electro magnet M, and U is the recording-wire, connected at $t'$ with the rotating axis of the dynamo $D'$. The main leads A B are connected with the diverging leads $A'$ $B'$ through the conductors $A^{13}$ $B^{13}$ $A^{14}$, carried out of the pathway of C from one end of the broken lead to its opposite connection.

The special construction shown in Figs. 4 and 5 outside the parts necessary to be shown to illustrate my present supply-service system form no part of the subject-matter of my present application, but are included in other applications now pending.

In Fig. 4 the lead B is made continuous for the main line, the current-gathering devices merely leaving it as the car diverges, connection with B of the side line being secured through the deflected conductor $B^{13}$.

In Fig. 5 is shown the car, in side elevation, partially broken away, showing also the roadbed. The car C′ may be of the ordinary form, having windows along the sides, seats within, and at the forward end a compartment for the motor-dynamo, in which the engineer who operates the same is placed.

It will be seen that my invention as herein shown and described is equally applicable to railways for the streets of cities or towns, for elevated railways extending along above the streets, for underground railways, and also for extended railways connecting distant parts of the country, whether, as I prefer, supplied through extended leads along the railway-lines and sliding contacts upon the motor-car or by storage-batteries carried upon the said motor-car for supplying electro-motive energy thereto, said storage-batteries supplied with electricity by the generating-dynamos at the various sub-stations of the line, said dynamos operated by the gas-engines of the parallel gas-supply system, as described.

It is also especially useful for tramways in mines, traction of canal-boats, and for many other purposes; also, that the means of supplying electric power are equally well adapted for arc or incandescent lights, or for running light machinery, and for public or private service in streets, squares, factories, stores, houses, or elsewhere.

I do not confine myself to the methods set forth in detail in this specification, but combine the several features of my invention in various ways and to best accomplish the object in view, and I variously modify the application thereof and the means used without departing from the principles of my invention, as herein shown, described, and claimed.

Having now described my invention, what I claim, and desire to secure by Letters Patent, is—

1. In an electric supply service, a series of conducting-leads extended from a central station and divided into two or more longitudinally-insulated sections forming independent circuits, in combination with a series of independent generating-dynamos, each dynamo contiguous to and supplying one of said sections, and a series of driving-engines, each contiguous to and operating one of said dynamos, each of said driving-engines operated by a source of power independent of and not derived from said central station, together with a series of electric conducting-wires connecting each of said sub-circuits with said central station, substantially as and for the purposes described.

2. The longitudinally-insulated electric leads A B, A′ B′, $A^2$ $B^2$, $A^3$ $B^3$, $l^6$ $l^7$, $l^8$ $l^9$, extended along the lines of an electric supply system to form a series of more and more distant sub-circuits, in combination with a parallel series of independent generating-dynamos, each adapted to supply electricity to one of said sub-circuits, and a series of fuel-gas engines, operated by the combustion of fuel-gas mixed with atmospheric air, each of said engines provided with a combustion-chamber and an incandescent igniter, S, adapted to cause said mixed gases to combine with heat and expansion and operate the piston of said engine, and each connected with and operating one of said dynamos, together with a line of closed fuel-gas-supply pipes extended along said supply system and provided with branch pipes supplying fuel-gas to each of said engines, substantially as described.

3. The compound fuel-gas and electric railway, consisting of a trackway and an electric supply-plant having a series of longitudinally-insulated conducting-leads extended along said trackway and adapted to supply electricity to an electric motor-car in contact therewith, in combination with a generating-dynamo contiguous to and supplying each of said sub-circuits, and a fuel-gas power-supplying service, parallel with said electric service, consisting of a line of fuel-gas mains extended along the lines of said conducting-leads, conveying a current of combustible gas with a pressure less than that required to operate said power-supplying device, said gas adapted to be mixed with atmospheric air to produce motive power by the combustion and expansion thereof, and a series of fuel-gas engines, each provided with a chamber for the combustible admixture of said fuel-gas, with a suitable proportion of atmospheric air supplied from the atmosphere at said station, and means for igniting said mixture in said engine, each coupled to and operating one of said dynamos, said engines supplied with said fuel-gas to furnish motive power for the same, substantially as described.

4. In combination with a central electric supply-service station having a generating-dynamo and a source of motive power to operate the same, and a series of longitudinally-insulated and independently-supplied electric conducting-leads extended therefrom to supply more and more distant parts, said insulated conducting-leads forming independent sub-circuits, a series of independent generating-dynamos contiguous to said sub-circuits and supplying electricity thereto, and a series of independent sources of motive power operating said dynamos, together with a series of electric conducting-wires independent of said insulated sub-circuits and extended from said sources of motive power along said lines of conducting-leads and operating through electro-magnets contiguous to said sources of power to set in operation or stop the motion of said generating-dynamo as a current of elec-

tricity is sent through said electric wires or the same are put out of circuit, substantially as described.

5. In an electric supply service, in combination with the central station, V, the sub-stations $V' V^2 V^3 V^4 V^5$, generating-dynamos $D' D^2 D^3 D^4 D^5$, and independent driving-engines $d' d^2 d^3 d^4 d^5$, located at said sub-stations, valves $e' e^2 e^3 e^4 e^5$, operated by electro-magnets $M M^{10}$, $M' M^{11}$, $M^2 M^{12}$, &c., arranged in pairs on opposite sides of said valves, said magnets $M M' M^2$, &c., operating to open said valves by acting upon armatures connected therewith, and said opposite magnets, $M^{10} M^{11} M^{12}$, &c., operating to close said valves by like means, the coils of said magnets charged through independent conducting-wires $T T^{10}$, $T' T^{11}$, $T^2 T^{12}$, &c., or their equivalents, extended along said supply service and provided with terminal electric contacts to turn on an electric current or cut the same off from said electro-magnets and open or close the supply-valves of said engines, substantially as described.

6. In an electric supply service for railway purposes, having a continuous trackway and electric conducting-leads divided into a series of longitudinally-insulated sections, in combination with a generating-dynamo and a source of motive power contiguous to each of said sections, and a motor-car moving upon said trackway in electric contact with said leads, the independent electric conducting-wires extended from the said source of motive power in opposite directions along the lines of other sections not operated thereby, adapted to be put in circuit by terminal contacts operated by the passage of the motor-car along other sections of said railway, said wires connected with electro-magnets and an armature controlling the supply-valve of said source of power, the whole so constructed that said motor-car, advancing upon a different section and operated by electricity generated by a different dynamo and driving-engine, will make contact upon one of said wires and start the engine and dynamo upon a section in advance, and when said car has passed beyond said section will insert the opposite contact and send back a current through the opposite wire to reverse said valve and stop said engine and dynamo, and so on successively, substantially as described.

7. In combination with the generating-dynamos $D' D^2 D^3 D^4 D^5$, located at various distant parts of an electric supply service, one or more independent electric conducting-wires extended from a central station to each of said generating-dynamos, said wires provided with detachable contacts operated by a moving part of each of said dynamos and adapted to make or break the circuit in said wires at definite intervals relatively to the operation of said dynamos, together with a recording or sounding apparatus in the circuit of said wire or wires at said central station, the whole constructed to operate substantially as and for the purposes herein shown and described.

8. In combination with the generating-dynamos $D' D^2 D^3 D^4 D^5$, located at different distant points along the longitudinally-extended conducting-leads of an electric supply plant, the electric wires $U U' U^2 U^3 U^4$, having breaks $t' t^2 t^3 t^4 t^5$ at said dynamos held in detachable contact with each other normally, so that a current will traverse the whole line $U U^4$, each of said dynamos provided with a circuit-breaker adapted to break the circuit in the wire $U U^4$ in a manner peculiar to itself while said dynamo is in motion, the whole so constructed that at each revolution of the armature of each dynamo mechanism connected therewith will be operated, and at regular intervals proportioned to the speed of said dynamo a record will be sent along said wire $U U^4$ to a recording-instrument, $t$, in contact therewith, and a characteristic record will indicate the speed of each dynamo of the series, substantially as described.

9. In combination with the independent generating-dynamos $D' D^2 D^3$, &c., of an electric supply service, the electrically-charged wire $U U^4$, having detachable contacts at each dynamo of said service held in contact with a rotating part, $D^{10}$, connected with said dynamos by springs and adapted to be instantaneously separated and closed at short intervals by a suitable circuit-breaker, with a number of rapid interruptions of current of greater or less number or length peculiar to each dynamo of the series, and the recording apparatus $t$, provided with a marking-point to mark a strip of paper passing under the same, the whole so constructed that each break of the wire $U U^4$ will cause the said point to mark upon the said strip a permanent record of the operation of each of said generating-dynamos at alternating intervals, substantially as and for the purposes described.

10. In combination with the rotating part of a dynamo-electric generator, the gear $D^{10} D^{11}$, electrically-charged wire $U'$, attached to spring-lever $U^{14} U^{16}$ and in electric contact with block $U^{12}$ of wire U, the toothed projections $U^{15}$ at one part of the circle $D^{12}$, having a definite size and spaces for each apparatus $t' t^2 t^3$, so constructed that the rotation of said dynamo will cause the gear $D^{10} D^{11}$ to rotate at a relatively-adjusted speed, the teeth $U^{15}$ to engage rapidly and successively at one part of the rotation of $D^{11}$ with the free end of the lever $U^{13}$ and break the circuit in the wire $U U'$ once or oftener, in a characteristic manner, for each dynamo, substantially as and for the purposes described.

11. In an electric supply service, in combination with a central station, V, and one or more generating sub-stations, $V^5$, supplying smaller circuits, $l^8 l^9 l^{10} l^{11}$, for special distribution of electricity, said sub-stations at distant points along the lines of said electric service, the electric key $T^{23}$ at said central station, and wire $T^{15}$, connected with the coils of an electro-magnet at said distant sub-circuit, together with a circuit-breaker, $M^{27}$, connected with the armature of said electro-magnet, operating to insert

or cut out said smaller circuit or circuits as said key is operated, substantially as described.

12. A gas-main extended along the lines of an electric supply service supplying fuel-gas under pressure to a series of gas-engines located at various distant parts thereof, said engines coupled to and operating a similar series of generating-dynamos along the same, in combination with one or more gas-blowers operated thereby and connected with said gas-main, said blowers operating to force the said gas along the same under suitable pressure adapted to convey the said gas to and supply the next succeeding engine or engines of the series, substantially as and for the purposes described.

13. The fuel-gas supply-main E, branch pipes $E'$ $E^2$ $E^4$, gas-reservoirs $G'$ $G^2$ $G^4$, check-valves $z'$ $z^2$, &c., and supply-pipes $E^{11}$ $E^{12}$ $E^{14}$, leading from said reservoirs and supplying combustible gas to the engines $d'$ $d^2$ $d^4$, located at various points along the line of gas-supply, in combination with a series of said engines, $d'$ $d^2$ $d^3$ $d^4$, operated by the combustion of a mixture of atmospheric air or other gases with the fuel-gas of said main E, said engines coupled to and driving the series of generating electric dynamos $D'$ $D^2$ $D^3$ $D^4$, substantially as and for the purposes described.

14. In an electric railway having a central station, V, and a series of independent sub-stations, $V'$ $V^2$ $V^3$, and the independent sub-circuits $A'$ $B'$, $A^2$ $B^2$, $A^3$ $B^3$, extended along the lines of said railway, the fuel-gas main E, parallel therewith and supplying combustible gas to a series of driving-engines, $d'$ $d^2$ $d^3$, for operating the same, in combination with a series of generating-dynamos coupled to and operated by said engines, and each dynamo supplying electricity to one of said sub circuits, together with a series of opposite electric wires extended from said sub-stations along said railway and provided with terminal contacts operated to make or break circuit in said wires, and electro-magnets and armatures connected therewith, operating to control the supply-valves of said engines as an electric current is sent through said wires and admit a supply of said gas to the combustion-chamber of said engines or cut off the same, substantially as described.

15. A supporting-structure for an electric railway, consisting of the trackway R R, extended along the same, having supports $J^5$ and a conduit, J, between said rails R R, and having longitudinal slot $J^3$ and electric conducting-leads A B within the same, supported by and insulated from said conduit, and the fuel-gas-conveying main E, extended along said railway, having lateral branch pipes $E'$, extended laterally from said main E to fuel-gas engines supplied thereby at various points along said railway, said gas-engines coupled to and operating dynamo-electric generating-machines to supply electricity to said conducting-leads at various points along said railway, said leads supplying electro-motive energy to an electric motor-car traveling along said trackway, substantially as described.

16. An electric-railway structure consisting of the trackway R R, supports $J^5$ $R'$, electric conducting-leads A B, and gas-main E, extended along the same, the longitudinal trough $J^7$, surrounding said gas-main E, the interspaces $J^9$, filled with an insulating substance, $J^9$, and the electric conducting-wires T U $J^6$ $l$ $l'$ $m$ $m$, contained within said trough, out of contact with said gas-main and insulated by said substance $J^9$, substantially as and for the purposes herein shown and described.

17. In combination with a generating electric dynamo and a fuel-gas engine contiguous to and operating the same, a fuel-gas main, E, extended from a relatively distant source of supply to said engine and supplying combustible gas to operate the same by its combustion, together with a valve controlling said supply of fuel-gas to said engine, said valve opened and closed by a pair of oppositely-placed electro-magnets attracting an armature attached to the same to and fro, each of said opposite electro-magnets provided with one or more electric wires extended from a relatively-distant point to said engine, said wires having terminal electric contacts adapted to insert or cut out the same, and through one or the other electro-magnet operate the said valve to start or stop the said engine and said dynamo, substantially as described.

18. In combination with a fuel-gas engine operated by the combustion of said gas, and a generating electric dynamo contiguous to and driven by said engine, one or more electrically-charged conducting-wires extended from said engine and dynamo to convey to a distant point intelligence of the operation of the same, and one or more electrically-charged conducting-wires extended from and operating the supply-valve of said engine by electric currents supplied through one or more terminal contacts, said wires extended to a distant point from said supply-station and controlling said engine therefrom, substantially as and for the purposes herein shown and described.

19. In combination with one or more fuel-gas engines and a fuel-gas-supply main conveying said gas from a distant source of supply to said engines, a trough surrounding said gas-main and containing one or more electric wires extended along the same, together with a mass of insulating material in said trough extended along said main, supporting and insulating said electric wires, substantially as and for the purposes described.

ISAAC W. HEYSINGER.

Witnesses:
J. L. HEYSINGER,
M. B. FENNINGER.