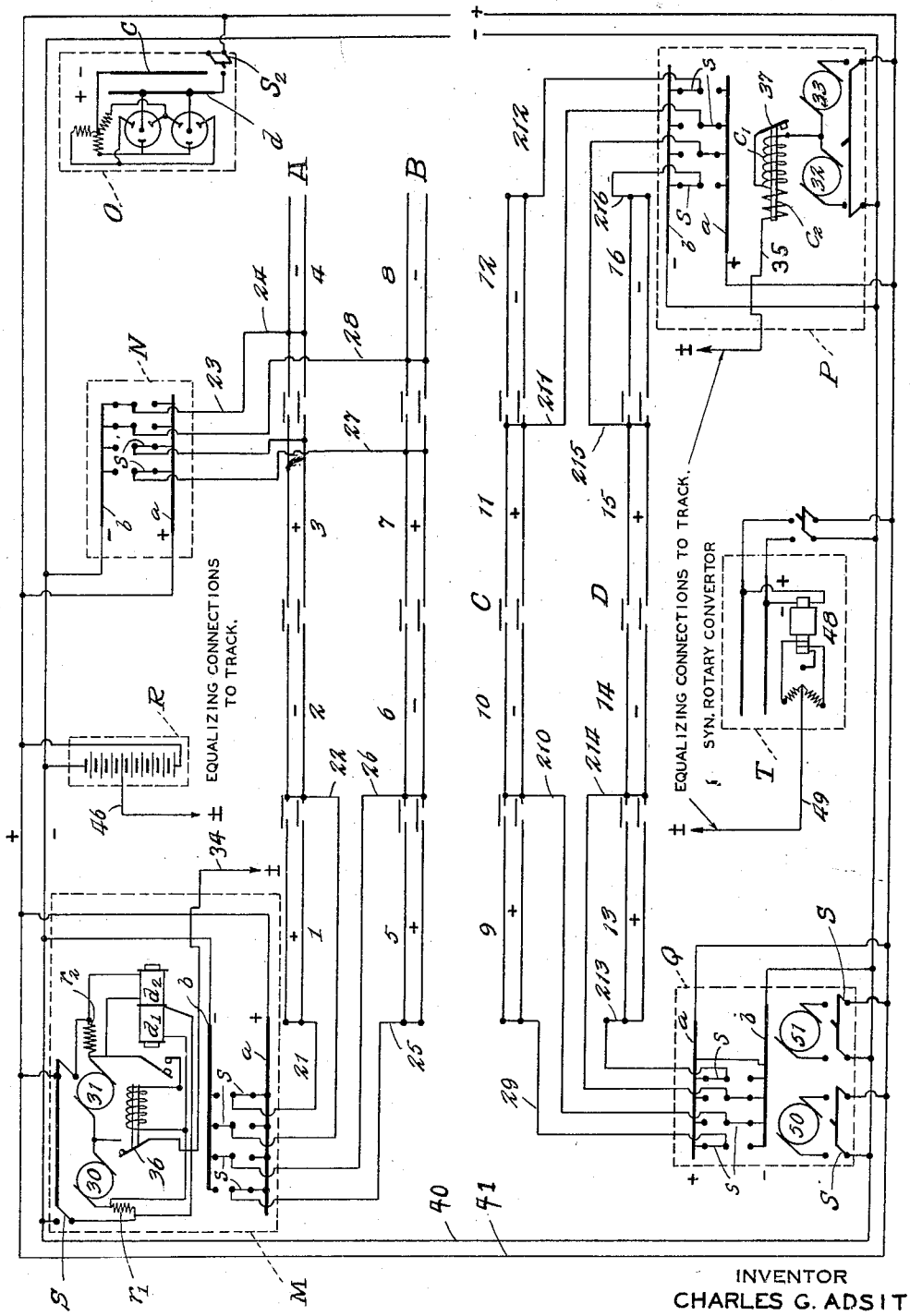
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POSITIVE AND NEGATIVE POWER FEEDING SYSTEM

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POSITIVE AND NEGATIVE POWER-FEEDING SYSTEM

Application filed June 10, 1930. Serial No. 460,240.

This invention relates to electric power supply systems and particularly to direct current supply systems for electric railways and is an improvement on the invention shown in the joint copending application of C. E. Bennett and myself, entitled "Electric power supply system", filed May 12th, 1927, Serial No. 190,866. In the system described in the aforementioned application, the trolley line is divided into mutually insulated zones or sections each of which is fed by a separate feeder. Some of said zones are of opposite polarity to others and the potential difference between zones of opposite polarity is twice that required by the motors in the electric railway cars, and the main current return is through the zone feeders. A small unbalanced current sometimes returns to the source through the track and through a balancing connection between it and the source.

In the large electric railway systems now in use, many sources of power are employed and these are often located at remote points in the system. The present invention has as an object the provision of means whereby some of the sources may be cut out automatically or at will so that only as many sources will be used as are necessary to meet the immediate demand, and thus the operating expenses of the system will be cut down, it being well known that it is more economical to operate one or two stations at their maximum output or nearly at their maximum output than to operate three or four stations at some point considerably below their maximum output.

It is another object of this invention to provide a system which will isolate trouble at any of the stations or at any source of power so that failure of any station, trolley, feeder or source of power will not materially affect the system as a whole.

Another object is to provide a system in which the sources of power and the power distributing apparatus can be separated and located in different stations.

Another object is to provide a positive and negative polarity feeding system provided with balancing or equalizing means, which means will become operative automatically upon a predetermined degree of unbalancing of the load and which upon resumption of normal balanced conditions will automatically become inoperative again.

In the single figure of the drawing I have shown diagrammatically a system of distribution of electric power for railways embodying the principles of my invention.

In the drawing I have shown the trolley wires of a double track electric railway which is divided into various branches A, B, C and D. The trolley wires of each of these branches are divided into mutually insulated sections or zones such as 1–16 inclusive. Several of these sections or zones, for example 1, 2, 5, 6, are connected,—each through their own separate feeder, for example, 21, 22, 25, 26,— to the distributing apparatus of a power supply station M. The other zones or sections are connected,—each by its individual feeder,—to distributing apparatus similar to that just mentioned, but in different stations, for example N, P, Q, located at different places in the railway system.

Each distributing apparatus consists of positive and negative station bus bars *a*, *b*, to which are connected the opposed stationary posts of single pole double throw switches *s* whose switch blades are connected to the feeders. Thus by merely throwing a switch the polarity of the current in a given zone may be reversed without affecting the polarity of the remaining zones. The potential difference betwen these bus bars is twice the potential rating of the trolley car motors so that, normally, current delivered to one section runs from the trolley wire down through the car to the trolley track and through it to the car on the nearest section which is being fed with current of opposite polarity. Thence the current normally returns to the source through the second mentioned car, its trolley line, and its feeder.

It will be noted that in each of the stations M and P there is, in addition to the distributing apparatus, a source of electric current consisting of two direct current generators—such as 30, 31, and 32, 33—which generate current at the rated potential of the trolley motors and which are connected together and

indirectly to the bus bars *a*, *b*, of those stations.

In case the cars are bunched at one spot on the system or the load is unequally divided, I provide connections 34, 35, whereby the unbalanced current may return to the source or equalizing current may be fed to the system. These equalizing connections (34, 35) run from the neutral point between the station generators 30, 31, or 32, 33, to the track.

A system similar to that just described is shown, described and claimed in the joint application Serial No. 190,866 hereinbefore mentioned, and is not claimed in the present application.

It will be noted from the drawing of my present invention that I employ positive and negative ring bus feeders 40, 41 which may entirely or partially surround or loop through the system and which are connected to the station bus bars of the various stations which I may employ, as herein described. By reason of this ring bus construction great flexibility of operation is given to the system and many advantages result.

One of these advantages is that the distributing apparatus and the source of power need not be located in the same station but they may be separated. Thus if it is found desirable to locate the distributing apparatus at a point in the system whereby reason of prohibitive property values or restrictive land covenants or the noise made by a power station it may be impossible to locate a power supply station, then the source of power can be located some distance away from and regardless of the location of the distributing apparatus. In an arrangement of that sort the station bus bars, *a*, *b*, of a station which contains distributing apparatus only,—for example station N,—will be connected to the ring busses 40, 41, and thus the zones which are controlled through station N may be fed current from the ring bus feeders. The station bus bars *c*, *d*, of a power station, such as O, will be connected to the ring bus feeders in order to feed current to the system as a whole, without restriction as to what sections of the system the current will ultimately reach and supply.

Because all the bus bars of the power supply and distribution stations are connected to the ring bus another advantage of the system develops, namely, one or more stations will suffice to supply current to the whole system during periods of light demand. The distributing apparatus of all the stations will always be used but the number of power units which need operate depends only on the demand. Thus the pieces of apparatus which operate at a given time will usually be operating somewhere near their full rating and hence they will be operating near their best efficiency.

For the purpose of disconnecting the power supply equipment from the ring buses, I provide suitable switches, S, in the leads between the generators and the ring buses. These switches and the single pole feeder switches *s*, although shown diagrammatically as hand operated, may be automatically operated from a master switch board (not shown) in a system control station (not shown) located wherever desired in the system, so that a load despatcher can control the whole system from one point.

As hereinbefore described the stations M and P have equalizing connections 34, 35 to the car tracks as in the system described in the aforementioned copending application. But in the present invention the equalizing or balancing connections may be normally open and the circuit through them only completed upon the occurrence of a predetermined amount of unbalancing. When this predetermined condition arises the circuit through the balancing connection is automatically closed by the closing of the normally open switches 36, 37 which are inserted in the balancing connections 34, 35 respectively. These switches may be operated in several ways only two of which are shown.

Switch 36 has its blade arm pivotally connected to the armature of an electromagnet whose solenoid is in an auxiliary circuit including the generators 30, 31 and controlled by a differential relay whose coils d^1 and d^2 are shunted around low resistance r^1 and r^2 which are in the main power leads from the generators 30, 31 to the ring buses 40, 41. Thus when there is an uneven demand for positive and negative current, the relay will operate to close the circuit through the electromagnet which in turn will close the switch 36 in the equalizing circuit and therefore the equalizing connection can function to balance the uneven demand.

Switch 37 is shown as controlled by an electromagnet having a solenoid composed of an operating coil c' and a series current coil c^2, the operating coil acting to close the switch when the current through it exceeds a predetermined amount and the series current coil acting to hold the switch closed until the current through it reaches a predetermined minimum. These coils are connected as follows. The operating coil c' is shunted directly across the equalizing switch 37 so as to be short circuited by that switch when it is closed. The series current coil c^2 is connected in series with the switch 37. The construction of these coils may be calculated according to well known formulas so that the coils will cause opening and closing of the equalizing or balancing circuit when desired. Since both coils c^1 and c^2 are in a continuously closed circuit from the neutral point between the generators to the track,—to wit, in the equalizing connection,—any unbalancing is reflected in them causing, when a prede-

termined degree of unbalancing occurs, closing of the switch 37, thus short-circuiting coil c^1, and thereby allowing the unbalanced current to flow freely through the equalizing connection 35.

Although the balancing or equalizing means just described in satisfactory and effective, it is not essential to the operation of my system. Ins ead, other balancing means may be provided as hereinafter described.

It will be noted that stations Q and O do not have any balancing connections. Station Q consists of two generators 50, 51 connected in parallel and delivering current to the ring buses 40, 41. These two generators generate power at twice the potential of the generators 30—33. Current is fed to the zone feeders 9, 10, 13, 14 through the stations' distributing apparatus which is like that in stations M, N, and P, already described. The station O, as already mentioned, has no distributing apparatus, the distribution of current to zones 3, 4, 7 and 8 being accomplished through distribution station N. The station O is a mercury arc rectifier station and the power generated therein is delivered directly to the ring buses 40, 41. A disconnecting switch S_2 may be provided to cut-off station O from the ring buses when the power from that station is not needed or wanted. If desired this switch may be remotely controlled from a load dispatcher's station (not shown).

If under some conditions it is desired to cut-out the power portions of stations M and P then it is desirable to have o her balancing means than those described in connection with stations M and P. I, therefore, provide stations R and T, which illustrate two types of balancing means separate from the main source of power. Station R contains simply a storage battery which floats across the ring buses and has a connection made from its mid-potential point, or thereabout, to the car tracks. When the load on the positive feeder is greater than on the negative or vice versa current flows from the positive pole of the storage battery or vice versa out on the system to take care of the extra demand. The connection from the track to the mid-potential point of the battery is an equalizing connection and it functions like the connections, 34, 35, but is a closed connection.

Station T contains a synchronous rotary converter 48 which delivers current to the ring buses, 40, 41. This converter need not necessarily be connected to a source of alternating current, but may float as a motor, on the ring buses. An equalizing connection 49 may be taken from the centre of the three phase star winding of the synchronous converter or transformer bank. The function of this station like station R, is to balance the system when the load becomes unequal on the positive and negative feeders. The equalizing connection functions in a manner similar to the balancing connections already described.

Although I have shown and described two ways to automatically complete the balancing or equalizing circuit to a main source of power, and two kinds of balancing stations, and power stations associated with distribution apparatus and a power station not having distribution apparatus, and power stations having no balancing or equalizing connection, it should not be inferred that my system is limited to the arrangement shown or to the specific types of balancing means or sources of power. I have shown different types to bring out the flexibility of my system and the variations which are possible in the type and placing of the apparatus used. Thus the types shown are alternative but they can be used conjointly as shown, to advantage, if desired. It should be noted that the flexibility and the ease with which my system can be controlled is largely due to the use of the ring buses.

The present invention differs in operation from the invention described in the aforementioned copending application in that the main current return in the present system is not always mainly through the negative zone feeders but it may under some conditions take numerous other paths, including ring bus feeders and equalizing connections. When the system is in balance the main current return will not be through the balancing connections but will be through the ring bus feeders and the zone feeders.

In operation, under light load it may be desired to use the power supply of only one or two stations, for example, station M may be sufficient. In that case current will be fed to the ring buses from which it will go to station bus bars *a* and *b* and from there it will go out to the feeders 21, 22, 25, 26 to zones 1, 2, 5, 6. The ring buses will conduct the current to the distribution station N and to the distribution apparatus in stations P and Q, the station bus bars of which are connected to the ring buses as hereinbefore described. From the distribution apparatus all the zones of the trolley line branches are fed by their own feeders as previously described. Thus it will be seen that the control of the polarity of the zones is always in the switches *s* and so long as current is fed to the ring buses that current can be transmitted to all the zones through the switches *s*.

When station M or station P or both are operating no balancing station is needed since stations M and P are each supplied with means to automatically establish an equalizing circuit upon the occurrence of a predetermined amount of unbalancing in the system.

When station O or station Q or both of

them are operating as the source of power, the power supply of stations M and P being cut out, it is desirable to use one or both of the balancing stations R and T to supply current to balance the system when the demand on the positive and negative feeders becomes noticeably unequal. It is advantageous to have the stations M, P, R, and T located at separated points in the system, for by so doing when the system becomes unbalanced by reason of an extra heavy demand at some point the balancing means nearest that point will operate to balance up the system, thus saving copper loss in transmission and tending to maintain the status of the rest of the system. In this way the automatic equalizing connections tend to localize the unbalancing. The equalizing connections 34, 35 also are useful when one or more of the balancing stations fail to operate.

It should be noted that in the system as described that the current values in the positive and negative ring bus feeders at a given point may differ widely, since each feeder is to a major extent independent of the other. It has been found in actual use where a rotary converter was used as a source of power, with the neutral point of its transformer bank connected to the track and its D. C. poles connected to the ring buses that twice full load current was delivered from one pole while no power at all issued from the other. Thus it will be seen that my system differs radically from single polarity feeding systems and prior double polarity feeding systems.

Of course, it is obvious that after the system has been balanced under operating conditions all the switches may be replaced by permanent connections, though in normal electric railway operation, it is desirable to retain the switches to insure the desired flexibility of the positive and negative system and in order to isolate instantaneously any section or zone on which a fault occurs.

It should also be noted that by manipulating the switches *s* so that all the trolley wire sections are positive or all are negative the system may be converted quickly into a single polarity feeding system using either the positive or the negative ring bus as the main feeder. It should further be noted that should the system become continually unbalanced on a certain section, the polarity of that section can be changed by merely throwing the switch *s* which controls it.

Many modifications within the scope of my invention will occur to those skilled in the art therefore I do not limit myself to the specific embodiment shown.

I claim:

1. In an electric railway system a plurality of trolley wires divided into mutually insulated zones, tracks associated therewith, a plurality of main sources of power, each normally feeding certain of said zones, and positive and negative power supply mains connecting all said sources and adapted to feed current to any or all of said zones at will.

2. In an electric railway system a plurality of trolley wires divided into mutually insulated zones, tracks associated therewith, a plurality of main sources of power, each normally feeding certain of said zones, and positive and negative power supply mains connecting all said sources and adapted to feed current to any or all of said zones at will, some of said zones being connected to the positive main and some to the negative main.

3. In an electric railway system a plurality of trolley wires divided into mutually insulated zones, tracks associated therewith, a plurality of main sources of power, each normally feeding certain of said zones, and positive and negative power supply mains connecting all said sources and adapted to feed current to any or all of said zones at will, and means to cut out any of said sources at will.

4. In an electric railway system a plurality of trolley wires divided into mutually insulated zones, tracks associated therewith, a plurality of main sources of power, each normally feeding certain of said zones, and positive and negative power supply mains connecting all said sources and adapted to feed current to any or all of said zones at will, some of said zones being connected to the positive main and some to the negative main, and means to cut out any of said sources at will.

5. In an electric railway system a plurality of trolley wires divided into mutually insulated zones, tracks associated therewith, a plurality of main sources of power, positive and negative supply mains connecting all said sources and feeding said zones, some of said zones being connected to the positive main and some to the negative, and a normally open balancing connection from certain of said main sources to track.

6. In an electric railway system, a plurality of trolley wires divided into mutually insulated zones, tracks associated therewith, a plurality of main sources of power, positive and negative supply mains connecting all said sources and feeding said zones, some of said zones being connected to the positive main and some to the negative, and a normally open balancing connection from certain of said main sources to track, and means in said balancing connections to close automatically the circuit through said connections upon the occurrence of a predetermined degree of difference in demand upon the positive and negative mains.

7. In an electric railway system, a plurality of trolley wires divided into mutually insulated zones, tracks associated therewith,

a plurality of main sources of power each normally feeding certain of said zones, positive and negative power supply mains connecting said sources and adapted to feed current to any or all of said zones at will, some of said zones being connected to the positive main and some to the negative main, and balancing means connected to said supply mains and having balancing connection to track.

8. In an electric railway system, a plurality of trolley wires divided into mutually insulated zones, tracks associated therewith, a plurality of main sources of power each normally feeding certain of said zones, positive and negative power supply mains connecting said sources and adapted to feed current to any or all of said zones at will, some of said zones being connected to the positive main and some to the negative main, a plurality of independently operable balancing means connected to said supply mains and having balancing connection to the tracks.

9. In an electric railway system, a plurality of trolley wires divided into mutually insulated zones, tracks associated therewith, a plurality of main sources of power each normally feeding certain of said zones, positive and negative power supply mains connecting said sources and adapted to feed current to any or all of said zones at will, some of said zones being connected to the positive main and some to the negative main, a plurality of independently operable balancing means connected to said supply mains and having balancing connection to the tracks, and means to cut out at will any of said main sources or said balancing means.

10. In an electric railway system, a plurality of trolley wires divided into mutually insulated zones, tracks associated therewith, a plurality of main sources of power located at separated points in said system, and each normally feeding certain of said zones, positive and negative ring bus feeders connecting said main supply sources and adapted to feed current to any or all of said zones at will, means to reverse the polarity of any zone at will.

11. In an electric railway system, a plurality of trolley wires divided into mutually insulated zones, tracks associated therewith, a plurality of main sources of power located at separated points in said system, and each normally feeding certain of said zones, positive and negative ring bus feeders connecting said main supply sources and adapted to feed current to any or all of said zones at will, means to reverse the polarity of any zone at will, balancing means connected to said ring bus feeders and having a balancing connection to the tracks.

12. In an electric railway system, a plurality of trolley wires divided into mutually insulated zones, tracks associated therewith, a plurality of main sources of power located at separated points in said system, and each normally feeding certain of said zones, positive and negative ring bus feeders connecting said main supply sources and adapted to feed current to any or all of said zones at will, means to reverse the polarity of any zone at will, balancing means connected to said ring bus feeders and having a balancing connection to the tracks, and means to cut out at will any of said main sources of supply.

13. In an electric railway system, a plurality of trolley wires divided into mutually insulated zones, tracks associated therewith, a plurality of main sources of power located at separated points in said system, and each normally feeding certain of said zones, positive and negative ring bus feeders connecting said main supply sources and adapted to feed current to any or all of said zones at will, means to reverse the polarity of any zone at will, balancing means connected to said ring bus feeders and having a balancing connection to the tracks, and means to cut out at will any of said main sources of supply and means to cut out at will certain of said balancing means.

14. In an electric railway system, a plurality of trolley wires divided into mutually insulated zones, tracks cooperating therewith, a plurality of stations, some of said stations being sources of power stations only, other of said stations being distributing stations only, positive and negative ring bus feeders connecting all said stations and being adapted to feed positive and negative current to said zones through said distributing stations, whereby some of said zones will be of positive polarity and other of said zones will be of negative polarity.

15. In an electric railway system, a plurality of trolley wires divided into mutually insulated zones, tracks cooperating therewith, a plurality of stations, some of said stations being sources of power stations only, other of said stations being distributing stations only, positive and negative ring bus feeders connecting all said stations and being adapted to feed positive and negative current to said zones through said distributing stations, whereby some of said zones will be of positive polarity and other of said zones will be of negative polarity, and other of said stations being both distributing stations and sources of power.

16. In an electric railway system, a plurality of trolley wires divided into mutually insulated zones, tracks cooperating therewith, a plurality of stations, some of said stations being sources of power stations only, positive and negative ring bus feeders connecting all said stations and being adapted to feed positive and negative current to said zones through said distributing stations,

whereby some of said zones will be of positive polarity and other of said zones will be of negative polarity, and other of said stations being both distributing stations and sources of power.

In testimony whereof, I have signed my name to this specification.

CHARLES G. ADSIT.