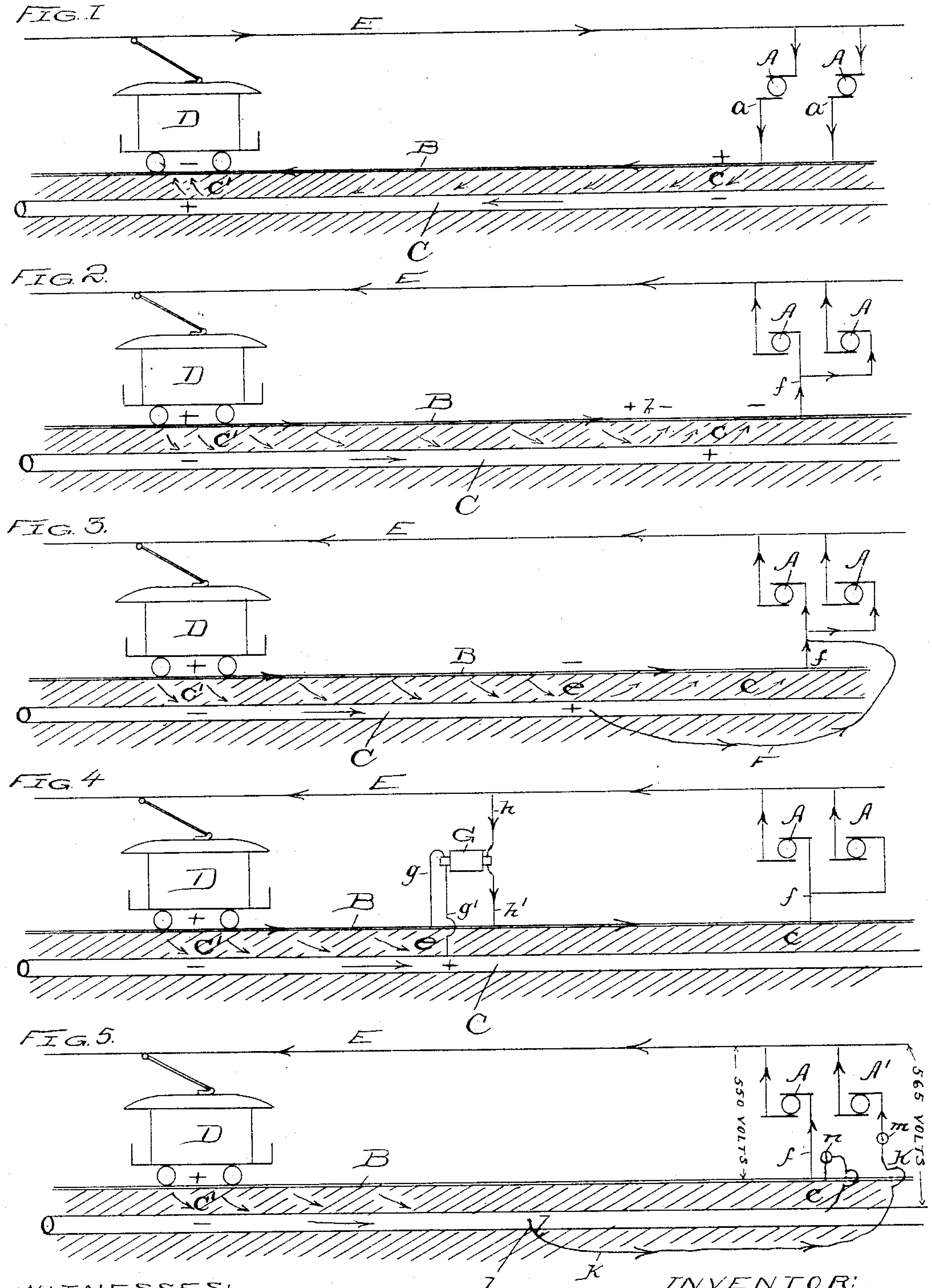
(No Model.)

H. P. BROWN.

METHOD OF PREVENTING ELECTROLYSIS OF PIPES UNDERGROUND.

No. 541,467. Patented June 25, 1895.



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METHOD OF PREVENTING ELECTROLYSIS OF PIPES UNDER GROUND.

SPECIFICATION forming part of Letters Patent No. 541,467, dated June 25, 1895.

Application filed December 10, 1894. Serial No. 531,346. (No model.)

To all whom it may concern:

Be it known that I, HAROLD P. BROWN, a citizen of the United States, residing at New York, in the county of New York and State of New York, have invented a new and useful Improvement in Methods of Preventing Electrolysis of Underground Pipes, of which the following is a specification.

My invention relates to means for preventing electrolytic decomposition of underground pipes.

In the present method of operation, the motors upon electric railway cars are driven by current received from a bare trolley wire and returned through the rails to the generating dynamos at the power house. In cities having water and gas pipes and other metal pipes for underground conduits, the return current divides between the rails and the pipes, since the moist earth forms a conducting path between them. As the pipes often form a complete net work of underground conductors while the lines of rails are less numerous, it often happens that the pipes carry a large portion of the current. This portion is increased by the corroding or mechanical breaking of the wire conductors or bonds joining the ends of the rails. Wherever the current leaves the pipes to complete the circuit, electrolytic action takes place, seriously decomposing and injuring the metal of the pipes. When an electric current is passed from one metal terminal to another through a conducting fluid like acidulated water, the fluid is decomposed, the oxygen in the fluid being set free at the outgoing or positive pole and the hydrogen at the negative pole. The oxygen at once corrodes the metal of the positive pole if capable of oxidation. Aside from this effect the current also tends to carry with it a portion of the metal of the positive pole, and, if the solution be one which will dissolve that metal, to deposit it upon the negative pole. The amount of metal oxidized or of metal carried away by the current itself is directly proportional to the amount of current flow and as this flow in cities may be measured by hundreds or even thousands of ampères, the injury inflicted upon iron and lead pipes is very extensive. It is true that it requires time for its effects to be felt but they are none the less severe as many cities are now realizing after having the electric railways in operation for three or four years. At first the traffic is comparatively light, and the bonds between rails are in good condition. The track is often ballasted with broken stone and it therefore requires considerable time to establish sufficient conductivity between rails and pipes to cause series trouble. Gradually however the moist earth surrounding the rails becomes permeated with gas leaking from the pipes below and with ammonia and animal salts from the surface. This increases the conductivity of the moist earth and the oxidizing process is set up. This by adding a solution of the oxidized metal to the moisture, still further increases its conducting power. Then the rusting of the rails at the points where the copper bond wires are connected, or the partial breaking of the bond wires themselves by the movement of the rails as cars pass over them, increases the resistance of the path through the rails and therefore diverts more current to the pipes. The corrosion ultimately produces deep holes in the iron pipes or in the lead calking of the joints in the same. If the out-going or positive current is carried to the rails this effect is produced near the ends of the railway lines. If the positive current is taken to the trolley wire, this effect is produced within a radius of two thousand to three thousand feet from the power house.

In order to clearly explain the nature of my invention, I have in the accompanying drawings, which form a part of this specification, illustrated at Figures 1, 2, 3, and 4 various methods which have heretofore been tried or suggested for overcoming the difficulty, and at Fig. 5 the system or method that I have discovered may be used with success.

The nature and difficulties of the problem, and the means or system which I have discovered as a practical solution will be readily understood by those skilled in the art from a brief explanation of the several diagrams, Figs. 1 to 5.

In Fig. 1, A represents the dynamos whose positive poles *a* are connected to the rail B. The current thus finds two paths, one through the rails B to the motor car D, and the other through the moist earth at *c* to the pipe C, and through the earth again at *c′* back to the rail B. Here the two currents unite and pass through the motor and trolley pole to the trolley wire E and back to the dynamos A, completing the circuit. In this case at c the rails will be positive, and the pipe negative, the rails therefore suffering from electrolytic decomposition, but since they are very heavy the effect does not serioul y weaken them. At c', however, the pipe is positive and the rail negative and the action is at the expense of the pipe and its lead calking. These are thin compared with the rails, and are also under pressure from water or gas whose leakage means serious loss in either case and is a source of danger in the case of gas. When the direction of the current is reversed as shown in Fig. 2, the rail is positive to the pipe at c' while the pipe is positive to the rail at c. This direction of the current is the preferable one as it concentrates the area in which the pipes are injured within a short radius of the power house, while with the other arrangement there is a corresponding area around the outer terminus of each line of rails. However a break in the rail bonds as at b may render the pipes positive to the rail at any point, but such breaks are easily detected and repaired. As the destruction of the pipes may not only occasion large expenditure in replacing them but may, by crippling the water supply at the time of a fire, be the cause of heavy losses, there have been many attempts to prevent electrolytic action. It was at first thought that by connecting the trolley wire to the positive pole, as in Fig. 2, the rail would present so good a return path that little current would reach the pipes. This was found a failure as the combined cross section of the pipes made so good a conductor that they carried a large portion of the current. Then a series of insulated feeder wires from one pole of the dynamos were run to various sections of the rails to add to their conductivity; but even this did not properly diminish the share of the current carried by the pipes. Then in many instances the rails and pipes were connected together at intervals. This made the pipes carry even a greater portion of the current, and as the contacts rusted between rails joints the current would flow from pipe to rail as each car passed, making it difficult to determine with electrical instruments upon the surface of the ground the electrical condition of the pipes. The amount of injury in any one section was thereby reduced but the area of injury was scattered all over the railway system. Then it was suggested that the current be run in one direction for a while and then reversed for a similar period. This was done on the supposition that the exact amount of metal carried off in one run would be replaced when the current was flowing in the opposite direction. This was absurd for three reasons, first, the greatest loss of metal is incurred by oxidation as above stated and this oxide cannot be electroplated upon another metal surface; second, to electrically deposit any metal, the fluid used must be a solvent of that metal, (such a solution is not encountered at random under city streets but only when especially made,) and, third, even if the same amount of metal taken off in one run was really carried back by the current in the next run in opposite direction, the metal would not be brought back to its position of departure. For instance in Fig. 1 the metal of the rail B for more than half its length would be carried over to the adjacent pipe; and within about two thousand feet from the end of the line the current would flow from the pipes to the rail at c' following the progress of each car. When the current was reversed, as in Fig. 2, only a small portion of it would flow to the pipes at c' where the greatest amount of metal was taken from the pipes in the previous case, since through the greater portion of the line the current would be flowing to the pipe. When within a short distance from the power house, as at c, the current would leave the pipes. The net result would be holes in pipes at c and c' and heavier pipes and rails in center of line. This is proved by actual measurements of the potential between rails and pipes and is not mere theory.

Another attempt to remedy the trouble is shown in Fig. 3. With conditions similar to those shown in Fig. 2, a feeder wire F is run from the negative pole of the dynamos to the point e on the pipes which showed the highest positive potential upon the pipe. It is evident that this wire to really protect the pipe, must offer a path of less resistance from e to f than the two rails B, or, in case there is a double track, than the four rails B; and even though it were of the same resistance as the rails, a heavy demand for current between e and f would make the pipe again positive. The corroding of the joint between the pipe and the wire F will have the same effect, and there will be no way of detecting at the power house the condition of this joint.

It is extremely difficult in the present state of the art, to maintain a low resistance joint between an iron rail or pipe and a copper wire as the two, in presence of moisture, form a galvanic couple which corrodes the iron, iron oxide being a bad conductor. The running of two overhead trolley wires would certainly protect the pipes, but as this system requires twice as many overhead wires as the other system, as it is much more difficult and expensive to maintain, and as it greatly increases the danger of fire by using two bare wires over each track with five hundred volts pressure between them, city authorities have generally refused to permit its use. It cannot therefore be regarded as a solution of the problem.

Another impractical suggestion has been made which is to use what is called in electric light and power distribution, the Edison three wire system. The modification for this purpose would divide the dynamos at the power house into two groups. The positive poles of the first group would be connected to the trolley wires over the "down" tracks and its negative to the rails and to the positive of the second group whose negative would go to the trolley wires over the "up" tracks. It is thus supposed that the load could be equally divided between the two groups and that therefore there would be little current carried by the rails to be shared with the pipes; but in practice it is impossible to divide the load evenly as in the morning the heavy traffic is all down town, and up town in the evening, and loads in different directions in different parts of the city could not be satisfactorily balanced against each other; but the chief objection would be that this system would require the use of two bare trolley wires with one thousand volts difference of potential between them. The dropping of a stray wire across the two would mean sufficient current flow to melt all three wires and drop them into the street.

Another proposed solution is shown in Fig. 4, in which at the point *e* where the pipe is positive to the rail, as in Fig. 2, a transformer G is placed with its primary circuit energized from the trolley wire to the rail through the wire *h h'*, and its secondary leading from the rail to the pipe through the wire *g g'*. The secondary is supposed to deliver sufficient current to cancel the effect produced by the leakage through the earth at *c'* from the rail to the pipe; but as this current on the pipes is frequently one-fourth to one-third of the total current the transformer G would have to represent a corresponding proportion to the dynamo plant A, and this in turn as well as the wire E, and section of rail B would have to be correspondingly increased. Without such increase the scheme would be inoperative since if the rail return in Fig. 2 is insufficient to operate the cars without sending a quarter of its current back on the pipes, it would be unable to convey the additional current to drive the transformer G when the pipes were prevented from doing their share of the work if such prevention should be possible.

Fig. 5 shows my improved method of checking electrolysis of the pipes. As in Fig. 2, the positive poles of the dynamos are connected to the trolley wire so as to bring the point *l* on the pipe, where the positive potential is highest, within a short distance from the power house. The dynamos A are connected as before to the rails by the wire *f* leading to their negative poles, and the pressure between the trolley wire and the rails is maintained constantly at say five hundred and fifty volts. The dynamo B, however, has its negative pole connected by an insulated feeder wire K to the pipes at *l* their point of highest potential, and the pressure between the trolley wire and the wire K is constantly maintained at say five hundred and sixty-five volts. The effect of this device is to always keep the pipes negative to the rails in spite of any variation of the load. For instance if the pipes at *l*, the point of highest potential, were in Fig. 2, seven volts positive to the rails and the fall of pressure in the wire K were three volts with maximum current when connected as in Fig. 5, then seven plus three or ten volts of the fifteen difference between rails and K would be used up in reaching the point *l*, and that point would therefore, be five volts negative to the rail at highest load and correspondingly more negative with a lighter load upon dynamos. The pipes C can never be of higher potential than the rail and therefore all chance of electrolytic decomposition of the pipes would be avoided. An ammeter *m* inserted at the power house in each pipe feeder wire K and a voltmeter *n* connected between pipes and rails would always indicate the electrical condition of the pipes and of the apparatus connected with the pipes. In case the wire K should be broken or contact at *l* corroded the ammeter *m* would show a decrease or stoppage of current and the voltmeter *n* would show a reversal of potential and a return to the conditions indicated in Fig. 2.

This invention not only protects the pipes from corrosion but actually results in a saving of motive power, for, as from a quarter to a third of the return current flows upon the pipes it must, in Fig. 2, pass through the resistance of the ground at *c*, and the passage of a current of hundreds of ampères through even a low resistance means a heavy loss.

In my invention, as shown at Fig. 5, not only is the low resistance wire provided for the passage of the current but a higher pressure is maintained at its end to induce the flow through it.

To give the results actually obtained in practice, at one power house when the total load was twelve hundred ampères average at five hundred and fifty volts when connected as in Fig. 2, it dropped to one thousand ampères when the connection was made, as shown in Fig. 5, when a current of four hundred ampères passed through the wire K. A saving was therefore effected of two hundred ampères at five hundred and fifty volts pressure or 147.4 horse power. When running, as shown in Fig. 2, the pipes at *l* were seven volts positive to the rail. During the run, as shown in Fig. 5, the pressure of dynamo B was kept at five hundred and sixty-two volts and the point *l* was then one and one-half volts negative. Evidently deducting the seven plus one and one-half or eight and one-half volts from twelve, the pressure between pipes and rail at power house, the remainder or three and one-half volts represents the loss due to the passage of four hundred ampères through the wire K. This was verified by calculating the loss in wire K and by the fact that with a less number of ampères through wire K the negative voltage on the pipes at *l* was correspondingly increased. It is evident that the amount of current flowing through the pipes can be reduced by carrying to the rails near the outer ends of the lines where they are ten or more volts positive to the pipes, a feeder wire from the negative terminal of dynamo B, with a greater negative potential than the rails have near the power house.

To make this system a permanent one a non-corrosive contact between water pipes and feed wires or between rails and feed wires must be provided, and this subject matter I reserve for another patent application.

I claim—

1. The system or improvement in the art of preventing electrolytic decomposition of underground metal pipes by the operation of electric motor street railways, consisting in the combination with the trolley wire, electric motor car, rails and underground pipes, of a dynamo plant having all of the positive poles connected with the trolley wire and some of the negative poles connected with the rails, said plant having one or more dynamos of higher potential with their negative poles connected with the underground pipes at or near the points on said pipes where there would otherwise be the highest positive potential, thus maintaining the underground pipes in a negative condition in respect to the rails and thereby preventing electrolytic decomposition of the pipes, substantially as specified.

2. The system or method of preventing electrolytic decomposition of underground pipes, consisting in maintaining said pipes in a negative condition in respect to the rails by connecting to the point on said pipes where there would otherwise be a positive potential, a feeder wire or conductor leading to the negative pole of a dynamo or other source of electrical energy, said pole having a greater negative potential than the rails, substantially as specified.

3. The system or method of preventing electrolytic decomposition of underground pipes, consisting in maintaining said pipes in a negative condition in respect to the rails by connecting said pipes to the negative pole of a dynamo of higher potential than the dynamo to which the rails are connected, substantially as specified.

4. The combination with a trolley wire connected with the positive pole of a dynamo plant, of rails B connected with the negative pole, and underground metal pipes connected with the negative pole of a dynamo of higher potential than that to which said rails are connected, substantially as specified.

5. The combination with trolley wire E of rails B, underground pipes C, electric motor D and dynamos A and A′, the latter of higher potential than the former, the negative pole of said dynamo A being connected with said rails B, and the negative pole of said dynamo A′ being connected with said underground pipes C, and an ammeter *m* inserted in the connection between said pipe and dynamo A′, substantially as specified.

6. The combination with a trolley wire connected with the positive pole of a dynamo A, of rails B connected with the negative pole, and underground metal pipes connected with the negative pole of a dynamo A′ of higher potential than that to which said rails are connected, said dynamo A′ having its negative pole also connected with said rails B at points distant from the power house, substantially as specified.

7. The combination with a trolley wire connected with the positive pole of a dynamo A, of rails B connected with the negative pole, and underground metal pipes connected with the negative pole of a dynamo A′ of higher potential than that to which said rails are connected, and a voltmeter *n* inserted in the connection between said pipes C and the rails B, substantially as specified.

8. The combination with a trolley wire connected to the positive pole of a dynamo A, of rails B connected to the negative pole, and underground metal pipes C connected to the negative pole of a dynamo A′ of higher potential than dynamo A, a voltmeter *n* inserted between said pipes C and rails B, and an ammeter *m* inserted in the connection between said pipes C and dynamo A′, substantially as specified.

9. The combination with a trolley wire connected to the positive pole of a dynamo A, whose negative pole is connected to the rails B of a dynamo A′ of higher potential than dynamo A of underground metal pipes C and a conductor K leading from said pipes C to the negative pole of dynamo A′ substantially as specified.

10. The combination with a trolley wire connected to the positive pole of a dynamo A, whose negative pole is connected to the rails B of a higher potential dynamo A′, whose negative pole is connected to pipe C and to rails B, the latter connection being made at a point distant from said dynamos, substantially as specified.

11. The system or method of preventing electrolytic decomposition of underground metal pipes or other conductors, consisting in connecting the points where the rails are of positive potential to the pipes and the points where the pipes are of positive potential to the rails, with the negative pole of a dynamo, said pole having a greater negative potential than the other dynamos of the plant, substantially as specified.

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Witnesses:

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