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PRESERVING UNDERGROUND PIPING

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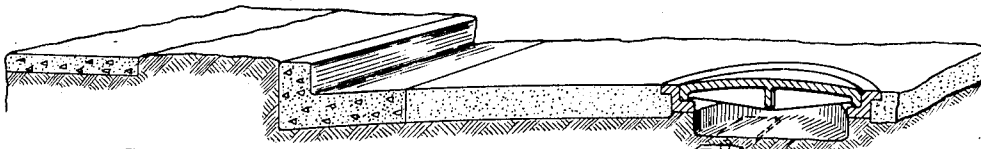


Fig. 1

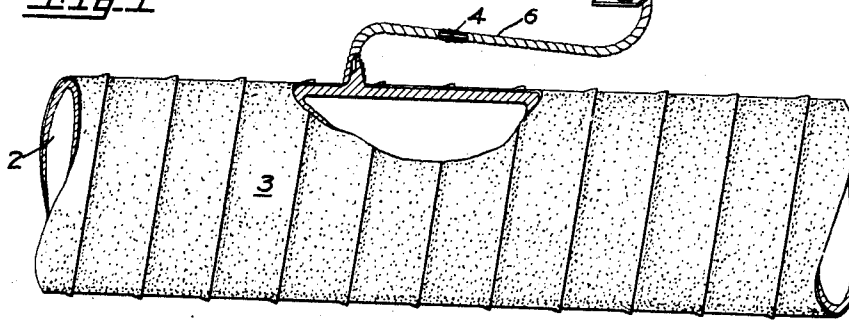


Fig. 3

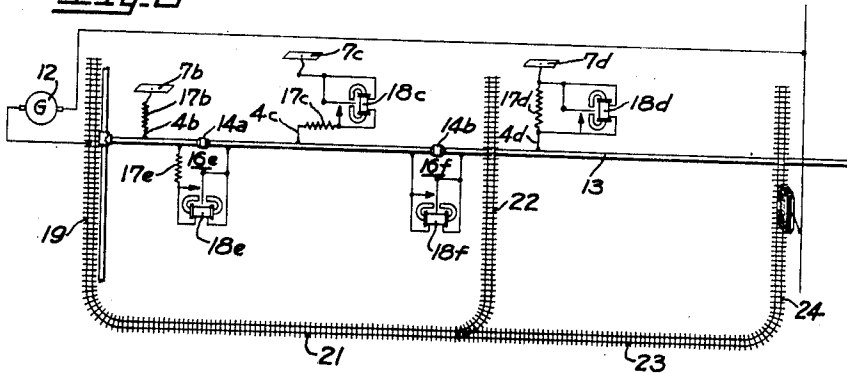
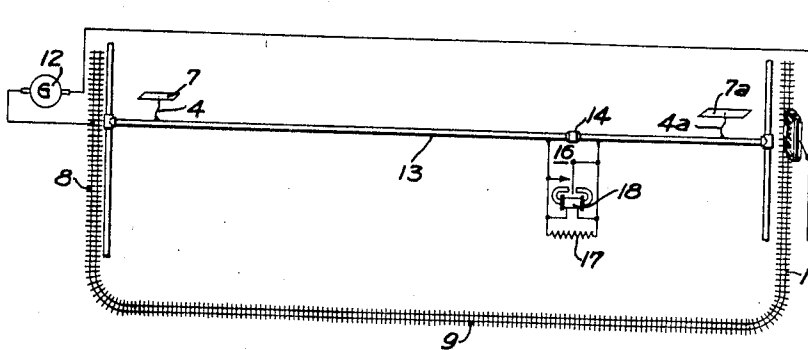


Fig. 2



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PRESERVING UNDERGROUND PIPING

Application filed May 17, 1926. Serial No. 109,539.

My invention relates to a method for preventing chemical disintegration, and especially to the prevention of corrosion and/or electrolysis of underground piping.

It is an object of my invention to prevent chemical disintegration of metallic bodies.

Other objects of my invention include the control of current flow between corrodible bodies and their surroundings; the prevention of current egress at other than predetermined and calculated portions of a corrodible body; and the provision of means by which these objects may be accomplished.

Another object of my invention is to teach a method, and one combination of means, for protecting pipe lines from the destructive effects of stray currents, and/or currents generated locally by chemical reactions.

It is a further purpose of my invention to teach a means for accomplishing the above desired objects at a commercially feasible cost.

My invention possesses other objects and features of advantage, some of which, with the foregoing, will be set forth in the following description of my invention, which is illustrated in the drawings accompanying and forming part of the specification. It is to be understood that I do not limit myself to the showing made by the said description, as I may adopt variant forms of my invention within the scope of the claims.

Referring to the drawings:

Figure 1 is an elevation of a portion of a pipe line, illustrating the connection of the bleeder in accord with my method, to an underground pipe line. Part of the pipe and insulation is broken away to disclose the bleeder connection.

Figures 2 and 3 are diagrammatic plans of applications of my method in protecting piping from stray currents from electric street railway systems.

The art of preventing chemical disintegration of piping and the like has in the past centered upon attempts to apply protective coatings to the metal, which were calculated to exclude air and moisture.

In an exhaustive series of tests on underground steel and wrought iron piping, it was

found that a difference of electrical potential invariably accompanied chemical disintegration of the piping; and the following conclusions were reached: (1) That in every case, such chemical action either produced, or was caused by, an electric current. (2) That either flow of current alone, or presence of moisture alone, is insufficient for such disintegration, but in the presence of an electrolyte such as common soil water, the rapidity of action is roughly proportioned to the quantity of current which is allowed, or caused, to flow. (3) That disintegration of the metal is substantially absent where current flows from the soil to the metal and is most evident where the current flows from the metal to the soil. (4) That the most durable protective coatings are, in general, those which are the best electrical insulators. (5) That failure of protective coatings may be caused by a phenomenon identical to that of break-down of electrical insulation.

In the change of iron from the metallic form to the material known as "rust" it is known that the iron must undergo removal from the parent mass of metal and that it departs therefrom in ionized form, carrying a positive electrical charge. The ferrous ion displaces hydrogen ions of the corresponding electrical equivalency which therefore formed a portion of the hydrogen ion content of the electrolyte, and these displaced hydrogen ions, under normal conditions, will give up their charges to some adjacent area of the same parent mass of the ferrous metal, which charge will pass, by the ordinary laws of electrical conductivity in metallic conductors, to the point from which the ferrous ion was abstracted with its positive charge, and will neutralize the electrically negative situation existing since the departure of the charged ferrous ion.

Repeated occurrence of this procedure results in:

1. The development of a considerable current flow in the parent body of ferrous metal.

2. A considerable loss of metal from the body of the ferrous metal at those areas which are anodic, i. e. which give off the ferrous ions.

As the displaced hydrogen ions must reach the metal to deposit their charge thereupon, any protective sheath interposed which will prevent their access to the metal will break up this cycle and thereby stop corrosive action. Correspondingly, such a protective sheath may stop the discharge of the ferrous ion into the electrolyte by preventing the electrolyte from coming in contact with the metal.

In the electrolysis due to currents from street railways a similar action may occur, but in this instance the charges departing from the iron by way of the ferrous ions are not returned to the same parent mass of metal but go elsewhere, usually on their route back to the power house or substation. Incoming quantities of electricity come to the corroding mass of metal from a source other than an area of the same piece of metal, or other pieces connected therewith, as in ordinary corrosion. But the reception of that current thru the mass of metal and its final departure by outgoing ferrous ions is an identical procedure, so far as the metal is concerned, in both instances. It will be appreciated that the metal need not be wholly ferrous, but much of this action will take place if a portion only is ferrous; or it may be enhanced by the presence of foreign metals; or it may occur in systems entirely comprised of metals other than iron or steel. My method involves the control of the currents set up and therefore as a preventive of corrosion it is also a preventive of electrolysis and vice versa. The fundamental purpose of my invention is to prevent disintegration no matter what its incidence may be.

This invention was prompted, and its chief fruits are realized, in the case of underground piping, where a certain amount of soil water is usually present, and where the moist ground itself is a conductor. Thus the conditions for continued action are complete, and the resulting problem of disintegration of underground piping is one to which no wholly satisfactory solution has yet been applied. It is estimated that in the United States alone the loss of pipe by corrosion is twenty million dollars annually. There are also added losses due to leakage, disruption of service and the like, as a direct result. It is proposed to show wherein the past efforts, involving the use of protective coatings, failed in an important respect to solve the problem; and to teach a practicable method for cutting down this enormous waste.

There are two possible angles of attack. Past effort has centered upon isolating the pipe chemically by coating it with waterproof paint, or by galvanizing it with zinc or other metal which is not infrequently passive to the corrosive influences of soils which will bring about a destructive action on protected iron

or steel. The electrical insulating quality of the former type of protective coating was an incidental feature to which scant attention was paid. This insulating quality however, is the basis for a second attack on the problem of protecting underground piping, and my method takes account of this. Chemical action may be prevented as well by preventing flow of current as by preventing access of the electrolyte to the metal of the pipe, and though I do not propose to prevent flow of current, I propose so to control its flow that its harmful effects will be avoided.

Consider the corrosion of the outside surface of an uninsulated pipe buried in moist soil. Positively charged ferrous ions leave the pipe at anodic areas due to the solution pressure of the iron and these ferrous ions almost instantly meet with negatively charged OH ions which remove them by reaction into insoluble $\text{Fe}(\text{OH})_2$, thus permitting more ferrous ions to break away from the pipe. This $\text{Fe}(\text{OH})_2$ is in turn acted upon by any of the indefinite number of constituents of the ground water, to form a generally insoluble complex compound or "rust". The greatest loss of ions appears to be at those points where oxygen is deficient, and so this incrustation of rust, by cutting off the access of oxygen to the area, enhances the previous favorableness of the situation as a seat for corrosion. This auto-acceleration of the rusting favors pitting, since the bottom of a pit is cut off from access to the air or oxygen carried by the electrolyte, while the oxygen around its rim acts as a depolarizer. This accounts for the continued corrosion of certain areas and the immunity of other areas, and it also accounts for the building up of a network of currents within a bare buried pipe and the observed phenomenon of a current which may travel along the pipe, possibly for miles, before it leaves it totally or only in part at an anodic area. It is important to note that only those currents flowing from the metal to the soil disintegrate the metal, while those currents which flow from the soil to the metal produce no effect upon the metal.

If the pipe had been coated with substantially waterproof paint, it would appear that since one of the elements necessary to any substantial rate of corrosion, namely the water or other electrolyte, has been intercepted, the problem would be solved. However, absolute waterproofing is a theoretical condition only approximated in practice. Even if all abrasion of the surface coating were avoided, there would be sufficient porosity to permit the seepage of a small amount of electrolyte to the piping surface. Assuming the ideal condition where all extraneous sources of potential are eliminated, this access of the electrolyte, even in minute amount, to the surface of the pipe may give a chance for the solution pressure of the iron to exert itself and

for the iron to go into solution in the electrolyte as ferrous ions. The repetition of this action over a period of time, granting the precipitation of the ferrous ion as a hydroxide or other insoluble iron compound at or near the point of its departure from the parent mass, will build up a quantity of products of corrosion under whatever protective coating is employed and the protective coating will be mechanically disrupted, allowing the electrolyte to reach the metal in increasingly greater quantities, and the corrosion will be further accelerated thereby. Such an insulated pipe line then may have a higher potential than the surrounding earth and this potential will not be a mere static condition but may be maintained in the presence of a not inconsiderable current flow. For instance, a current flow of 1000 coulombs per month may be thus maintained. Such a current flow might produce a metal removal of 20 grams in five years which, in the case of a pipe with thin walls, would certainly bring about a puncture of the wall. Thus it is seen that an ordinary paint-coated pipe even under such a favorable condition as this, where no outside potential is imposed upon the pipe, will not be proof against disintegration. The same is true with asphalt-dip coating. Until recent times, no coating which produced a highly insulating effect of durable character was available. I have found that even such a covering as the double wrapping of specially prepared asphalt-impregnated felt, described in my co-pending application #656,125, series of 1915 filed August 6, 1923, will not absolutely prevent flow of current therethru.

So far, only those potentials induced by the chemical reaction itself, have been considered. There are however, other sources of potential which can cause initial failure of an insulating waterproof coating; probably the principal ones of which are "stray" currents and induced currents. "Strays" are most frequently caused by connection of electrical machinery to "ground". Figures 2 and 3 illustrate examples of this source of stray currents in street railway systems. In extreme cases potentials as high as 30 volts have been observed from this source. There are no coatings or coverings of commercially practicable price which can permanently resist such differences of potential as this when buried in wet soil, for the traces of moisture which are gradually absorbed by any coating under such circumstances make it vulnerable.

I therefore propose to insulate the pipe or other structure to be protected, by wrapping or otherwise, so far as it is practicable to do so; and in addition to this protective coating, I provide preferably metallic bleeders which are connected electrically to the pipe, and keep it drained of high electrical potential.

Of course the "grounding" of structures is

necessary for protection against lightning and short circuits, but such practice does not suggest the use of bleeders in accordance with my invention.

Until the invention of wrapped coverings of the type described in my said co-pending application, no satisfactory insulation was available for controlling the path of current thru a pipe; and current might leave the pipe at a large number of points other than a specially prepared avenue of escape. Thus my method realizes its fullest possibilities with the use of such an insulating covering on the pipe.

Figure 1 illustrates a portion of pipe line formed of metal pipe 2. The surface of the pipe is insulated and waterproofed by a resistant covering 3, preferably of spirally-wrapped bitumen-impregnated felt, as described in my said co-pending application. A metallic stem or bleeder 4 is welded to the metal pipe 2 by any well-known means, and this stem is thoroughly insulated electrically by a bituminous wrapping 6. The stem is welded or otherwise electrically well connected at its terminus, to a bare grounding plate 7 of metal, carbon, or other substance which will form a suitable anodic ground. The grounding plate should be buried in moist, or otherwise good conducting earth, and for convenience of inspection and replacement, it is placed in an easily accessible position. Experiment will indicate that different areas of the ground may vary appreciably in potential, and it is desirable to position the grounding plates in a relatively low potential area.

The bleeder 4 prevents rise of potential of the pipe to values above the safe limit of the insulation 3, and provides a harmless exit for any currents which may occur in the pipe. Thus the insulation tends to protect the pipe from outside sources of current and in turn is protected from currents within the pipe which cannot be wholly prevented.

Since disintegration of the metal takes place only when electric current flows from the metal to the soil, it is obvious that the pipe itself will be protected from chemical action by thus carrying the current away thru the bleeders. Moreover, it is immaterial to the operation of my method whether the current is induced by chemical action as in corrosion, or whether the current is the cause of the action, as in electrolysis. The cure in either case is to control the current.

It is obvious of course, that in this case chemical action will be transferred to the grounding plates 7, and these must be constructed to withstand it. They may be of any convenient form and of a variety of materials. It is generally contemplated that scrap iron will be used for this purpose, and will be made accessible for inspection and replacement. It is known that good results

may also be obtained with the use of a non-corrosive conductor such as carbon, nichrome, or the like. In fact, any readily replaceable, specially protected, or especially massive conductor, or even such a portion of the pipe itself, may be used as the grounding connection.

So far, that type of disintegration which is actually caused by outside electrical influences has not been considered in detail. These extraneous sources of current not only tend to break down insulation of the pipe, but also cause serious electrolysis of the pipe itself.

Take the case illustrated by Figure 2, of an electric railway line 8, 9, 11, which uses a rail return in the electric circuit to the generator station 12. A pipe line 13 in the ground, lies in close proximity to the generator and to a remote portion 11 of the railway line, so that the pipe line forms the shortest ground return between this portion of the electric railway line and its generator station. In such a case, and especially where the rails are poorly connected, the quantity of the stray currents picked up and carried by the pipe may be considerable. In general, the current will flow thru the ground and enter the pipe near the section 11, and will leave it near the generator 12; at which latter point rapid electrolysis of the metal will take place; assuming of course, the use of unprotected pipe. In this case a painted coating or an asphalt tar dip would be almost useless and even a double covering of the material described in my co-pending application No. 656,125 above referred to, would probably undergo an electrical and physical breakdown if the difference of potential between pipe and rail were of an order of magnitude of 12 volts and the soil were more than distinctly damp, though not of necessity even wet.

Figure 2 then, illustrates the application of my method to an important case of protecting objects from stray currents. A bleeder 4 should be connected to the pipe line 13, near the generator station 12, for this would normally be a low potential area of the ground, where the current tends to flow from the pipe. A grounding plate 7 is used for the bleeder terminal, and the manner of connecting and placing the bleeder is the same as that illustrated in Figure 1. When the potential of the ground in the vicinity of section 11 is higher than at section 8, current which leaks into the pipe thru the insulation at section 11 will flow harmlessly out thru the bleeder near section 8.

A bleeder 4a leading to a grounding plate 7a, may be provided near section 11. Its purpose is first, to prevent breakdown of insulation where the current enters the pipe, and second, to take care of a freak condition of inversion of potential at sections 11 and

8, such as might occur at night when the street cars stop running. The use of a plate such as 7a, which is normally cathodic, but which may become anodic at times is to be undertaken with due regard to the conditions to be met. Generally I would prefer to install an insulated coupling 14 in the line 13 if a normally cathodic plate is to be employed. Such an electrically insulated coupling may be of any well known type obtainable on the market or may be made with a steel or cast iron shell with concrete used as a jointing material. A coupling of this character will limit the amount of current flowing in the pipe and therefore prevent excessive and needless wasting of the anodic plates. But the use of insulated couplings is attended with certain dangers since a dangerously high potential may build up on the positive side of such a coupling as compared to that on the other side and there may be a tendency for current to leave the pipe, go around the coupling and return to the pipe again, traveling past the coupling via the surrounding moist earth. Where such a current leaves the pipe there will be metal loss. In such a case several insulated couplings may be employed at or near the place of the single coupling 14. The drop of potential around any one of the several may thus be kept below a dangerous figure.

My method also permits the use of various means supplemental or alternative to the insulated coupling for controlling current. In Figure 2 I have illustrated a shunt 16 across the coupling, and a resistance 17, of determinedly adjusted value in this shunt. The value of this resistance must be adjusted with due regard to existing conditions such as of pipe and soil potential, which are not the same in different installations. This shunt permits a limited current flow to bleed away the dangerous peak voltages.

A polarized or other current-direction-controlled switch 18, or a time controlled switch, or even a manually operated switch, may also be provided either in parallel or in series with the resistance, or it may entirely displace the resistance in the shunt 16. These connections are illustrated in the several couplings 14, 14a, and 14b respectively in Figures 2 and 3.

It is apparent that, due to the presence of the insulating coupling 14, a certain potential will build up on the positive side of said coupling. When this potential reaches a sufficient value, the current will energize the switch and cause a momentary closing of the circuit. The value of the current necessary to do this is dependent upon the value of resistance 17. As this occurs, the accumulated charge is dissipated, and the switch magnet is de-energized, thus allowing the spring arm of the switch to open and re-establish initial conditions, except that there is no longer an ac-

5 cumulated charge on the positive side of the coupling. The switch will remain open until the charge again accumulates to a value sufficient to energize the switch, when the same conditions will re-occur.

10 A similar choice of set-up is possible in connection with each bleeder, and in Figure 3 I have diagrammed a hypothetical set-up illustrating such combinations. An insulated pipe line 13 is in proximity to a railway line 19, 21, 22, 23, 24 having its generator station 12 near section 19 of the railway. Bleeders 4b, 4c and 4d with their grounding plates 7b, 7c and 7d, provide points of egress for 15 currents from the pipe line. Resistances 17b and 17c of values adjusted in accord with the other factors previously mentioned, are interposed in the bleeders 7b and 7c to distribute the load between bleeders. A current-direction-controlled switch 18c is provided in bleeder 4c in series with its resistance, to prevent influx of current to the pipe at this point which is subject to inversion of potential. The bleeder 7d is provided with a resistance 17d and current-direction-controlled switch 18d in parallel, allowing free egress of current and limiting its possible ingress to the pipe. Insulated couplings 14a and 14b between each bleeder, separate the pipe into 20 controllable sections, and have shunts 16e and 16f around them. The shunt 16e has a resistance 17e and current-direction-controlled switch 18e in series, and the shunt 16f has its resistance reduced to a negligible value and is provided with a current-direction-controlled switch 18f. As a rule, it will not be necessary or even advisable to combine all these safeguards in any single limited area of a 25 system such as this. It is to be understood that my method contemplates a proper determination of the conditions encountered in any case, and teaches the means with which to meet these conditions.

30 In all of this it is understood that the object of the various devices used is to reduce the accumulation of a high positive potential on or at any point or area of the nominally insulated pipe in conjunction with a potentially large current whereby a considerable volume of metal removal might be brought about. Of course I have illustrated simple ideal systems in the drawings and specifications. In practice there may be many 35 branches of one or more street car systems which pass over or near or which parallel buried pipe lines and there may be many points on a single line which are normally anodic instead of just one or two points, as hereinabove discussed. But voltage measurements, and where possible ammeter measurements, will reveal that the pipe surface is either anodic or cathodic, or suffers periodic alternation between these two states, and it is 40 believed the above methods of treatment provide for any and all of these three conditions.

45 Different portions of a pipe, and especially of a long pipe line, will vary appreciably in electrical potential. It is the intent of my invention to connect the bleeder or bleeders to a relatively high potential portion of the pipe where other conditions make this feasible. It is furthermore the intention, as suggested by Figure 2, to bury the ground plates in a relatively low potential area of the ground, it being well known that different 50 areas of the ground, especially that subject to the influences of electrical machinery, will be at different potentials. The factors governing these potentials are manifold, and it is advisable to determine the relative potentials in each case by experiment.

55 It is understood that there are sources of destructive currents other than that illustrated by Figures 2 and 3. In general it may be said that regardless of the source, if it is found that a pipe is at a higher potential than the surrounding earth and a sufficient current flow occurs to be a potential cause for serious chemical disintegration, the situation may be brought under control by insulating the pipe by means of the covering 60 above referred to, and installing a bleeder to take the current to a point removed from the pipe itself and there distribute it to the surrounding earth by a renewable corrodible or non-corrodible plate.

I claim:

1. A system of pipes in a medium carrying a plurality of currents, insulating covering on said pipes, non-conductive couplings electrically separating said system of pipes into sections, shunts of determinedly adjusted resistance around said couplings, switches in combination with said shunts for controlling flow of current around the couplings, 65 and a plurality of bleeders electrically connecting portions of said system of pipes to portions of said medium which are at lower electrical potential than the said portions of said system of pipes, whereby the electrolytic corrosion of said system of pipes may be materially reduced.

2. A system of pipes in a medium carrying a plurality of currents, insulating covering on said pipes, non-conductive couplings electrically separating said system of pipes into sections, shunts of determinedly adjusted resistance around said couplings, current-direction-controlled switches in combination with said shunts, and a plurality of bleeders electrically connecting portions of said system of pipes to portions of said medium which are at lower electrical potential than the said portions of said system of pipes, whereby the electrolytic corrosion of said system of pipes is materially reduced.

3. A system of pipes in a medium carrying a plurality of currents, insulating covering on said pipes, non-conductive couplings electrically separating said system of pipes into 70 75 80 85 90 95 100 105 110 115 120 125 130

- sections, shunts around said couplings, switches in series with said shunts, and a plurality of bleeders electrically connecting portions of said system of pipes to portions of said medium which are at lower electrical potential than the said portions of said system of pipes, whereby the electrolytic corrosion of said system of pipes is materially reduced.
- 10 4. A system of pipes in a medium carrying a plurality of currents, insulating covering on said pipes, non-conductive couplings electrically separating said system of pipes into sections, shunts around said couplings, current-direction-controlled switches in series with said shunts, and a plurality of bleeders electrically connecting portions of said system of pipes to portions of said medium which are at lower electrical potential than the said portions of said system of pipes, whereby the electrolytic corrosion of said system of pipes is materially reduced.
- 15 5. A system of pipes in a medium carrying a plurality of currents, insulating covering on said pipes, non-conductive couplings electrically separating said system of pipes into sections, shunts of determinedly adjusted resistance around said couplings, switches in combination with said shunts for controlling flow of current around the couplings, and a plurality of bleeders electrically connecting portions of said system of pipes to portions of said medium which are normally at lower electrical potential than the said portions of said system of pipes, and current-direction-controlled switches interposed in said bleeders, whereby the electrolytic corrosion of said system of pipes may be materially reduced.
- 20 6. A system of pipes in a medium carrying a plurality of currents, insulating covering on said pipes, non-conductive couplings electrically separating said system of pipes into sections, shunts of determinedly adjusted resistance around said couplings, current-direction-controlled switches in combination with said shunts, and a plurality of bleeders electrically connecting portions of said system of pipes to portions of said medium which are normally at lower electrical potential than the said portions of said system of pipes, and current-direction-controlled switches interposed in said bleeders, whereby the electrolytic corrosion of said system of pipes is materially reduced.
- 25 7. In an insulated pipe line, an insulating coupling interposed in said pipe line, and a determinedly adjusted resistance shunted across said coupling, and a switch in combination with said resistance shunt for controlling current flow around the coupling.
- 30 8. In an insulated pipe line, an insulating coupling interposed in said pipe line, and a determinedly adjusted resistance shunted across said coupling, and a polarized switch in combination with said resistance shunt.
- 35 9. In an insulated pipe line, an insulating coupling interposed in said pipe line, and a determinedly adjusted resistance shunted across said coupling, and a polarized switch in series with said resistance shunt.
- 40 10. In an insulated pipe line, an insulating coupling interposed in said pipe line, a shunt across said coupling, and a switch in combination with said shunt for controlling the current flow around the coupling.
- 45 11. In an insulated pipe line, an insulating coupling interposed in said pipe line, a shunt across said coupling, and a polarized switch in combination with said shunt.
- In testimony whereof, I have hereunto set my hand.
- DOZIER FINLEY.

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