WHY SNOW MAKING PIPES CORRODE

CORROSION SERVICE
COMPANY LIMITED

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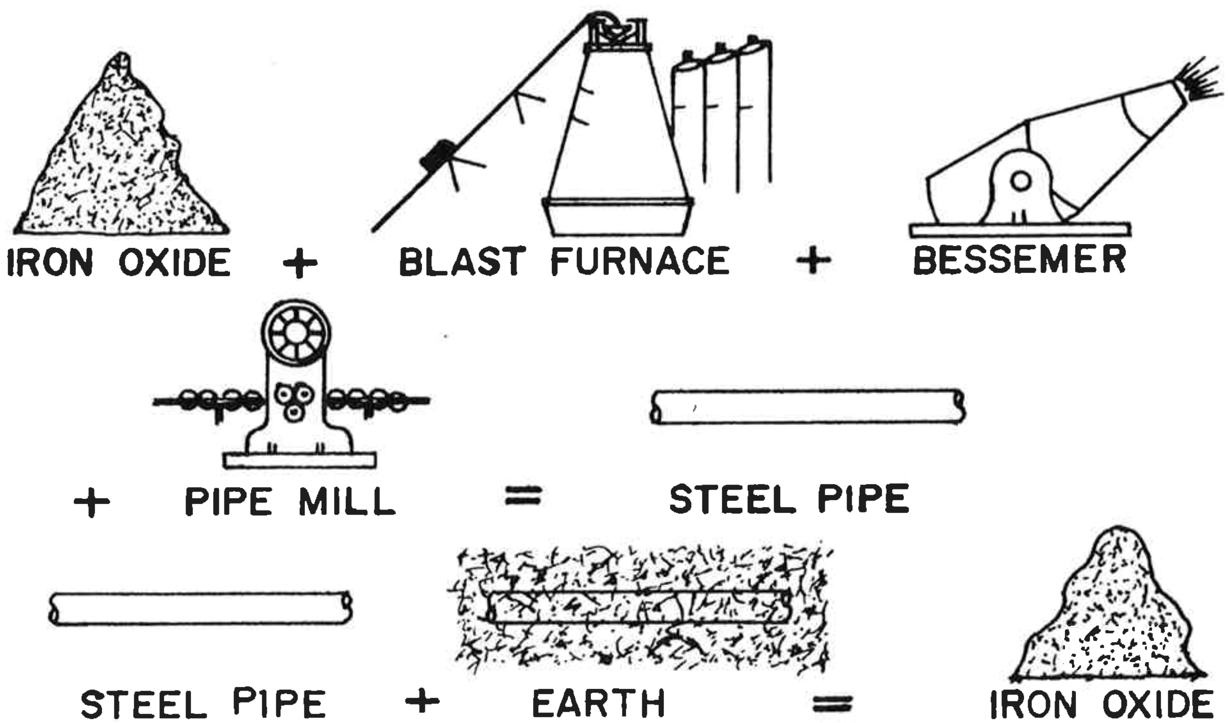
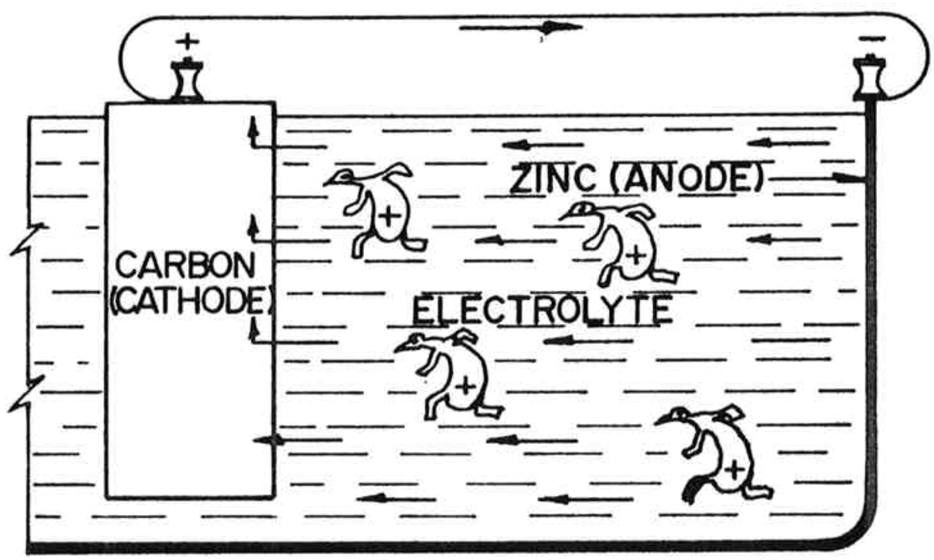
WHY SNOW MAKING PIPES CORRODE

This paper will concern itself with the very basic fundamental causes of corrosion and its prevention. The fact is that metals corrode through sheer cussedness. They want to corrode. This perverse desire stems from the fact that it is more natural for a metal to exist in the form of a compound, since compounds such as oxides contain less energy than metals and are therefore more stable.



In the making of steel, when iron is divorced from its associated oxygen in the blast furnace, a lot of energy is put into it in the form of heat. As long as it remains metallic, a piece of steel retains a portion of this energy, bound up within itself, always urging the metal to corrode back to the ore from which it was unwillingly derived. It is this energy which supplies the power to drive the various corrosion reactions and which provides the incentive to corrode. When steel rusts the latent energy is released and the metal, relieved of its uneasy hypertension, thankfully reverts to a stable oxide again, and the cycle is complete.

When steel rusts the union with oxygen does not take place directly but by a rather roundabout series of reactions in which the passage of an electric current plays an important part. It is often stated that corrosion is caused by electric currents. It is perhaps more accurate to say that in most cases the electric current is caused by the corrosion, but the two are as interdependent as the chicken and the egg.



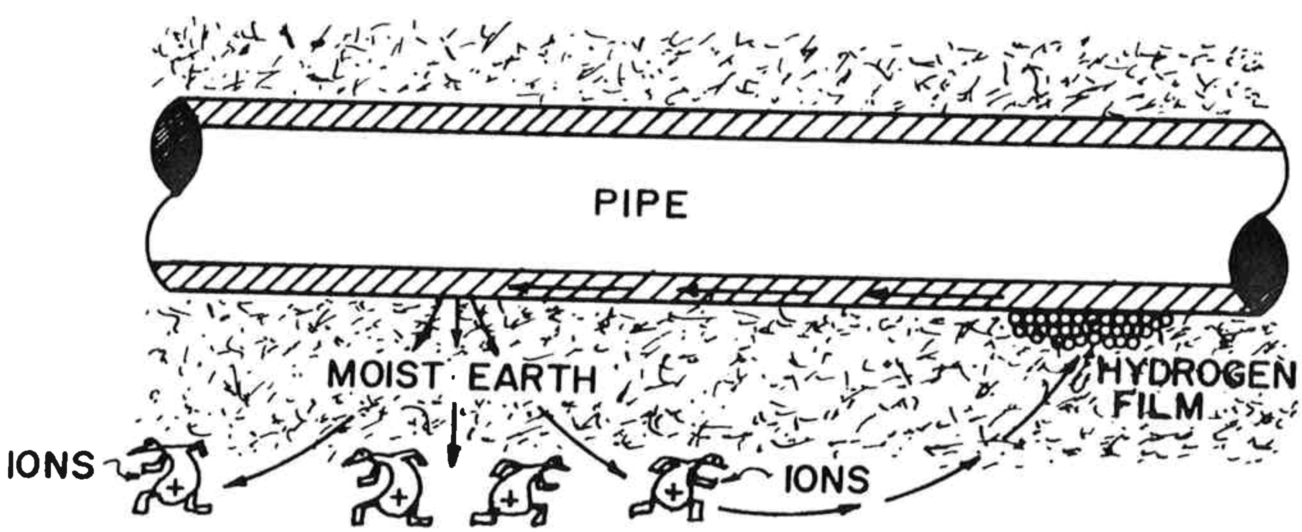
BATTERY ACTION
(GALVANIC CELL)

A very good example of the way current can be generated by corrosion is that of the galvanic cell. Take the case of the ordinary dry cell battery, which consists of a zinc can holding a moist paste which constitutes the electrolyte, in the centre of which is a graphite rod which acts as the cathode of the cell. By reason of the fact that the zinc has more stored up energy than has the graphite and is thus more anxious to corrode, a potential of about 1 1/2 volts exists between the zinc and the graphite, and if the external terminals are joined with a wire, current will flow in the cell from the surface of the zinc through the electrolyte to the cathode and back again through the wire. If a flashlight bulb is put in the external circuit it will light, and it is interesting to note that the electrical energy which lights it is the energy of corrosion of the zinc, and the same energy which was put into the zinc when it was refined from its ore. As the zinc corrodes, it releases into the electrolyte small charged particles of itself, called ions, and these travel across the cell to the cathode where they become discharged. The passage of ions constitutes an electric current. The more current flowing in a cell, the more zinc is corroded. After the battery has been used for some time, corrosion will eat a hole in it, and the cell will leak. Most people have had the experience of having a flashlight battery leak inside the case.

If the wire is disconnected from the external terminals the current is interrupted and the ions released at the surface of the zinc have nowhere to go and accumulate in such numbers that corrosion is virtually stopped. This points out that for corrosion to take place there must be a complete electrical circuit.

Notice that only the anode is attacked in every electrolytic cell. The anode is the place where the current leaves the metal to go into the electrolyte. The cathode is the place where the current flows back out of the electrolyte. For every anode there is always, somewhere, a cathode. Anodes corrode: cathodes don't.

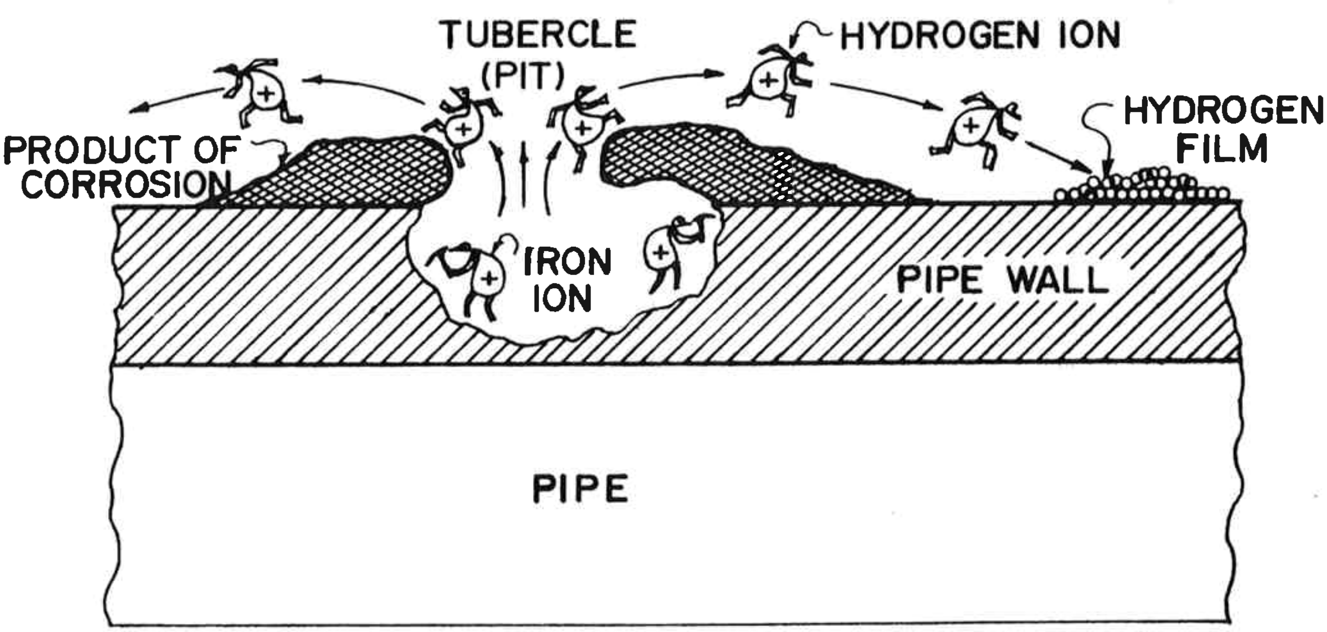
THE HYDROGEN ION



IONS IN MOTION CONSTITUTE AN ELECTRIC CURRENT

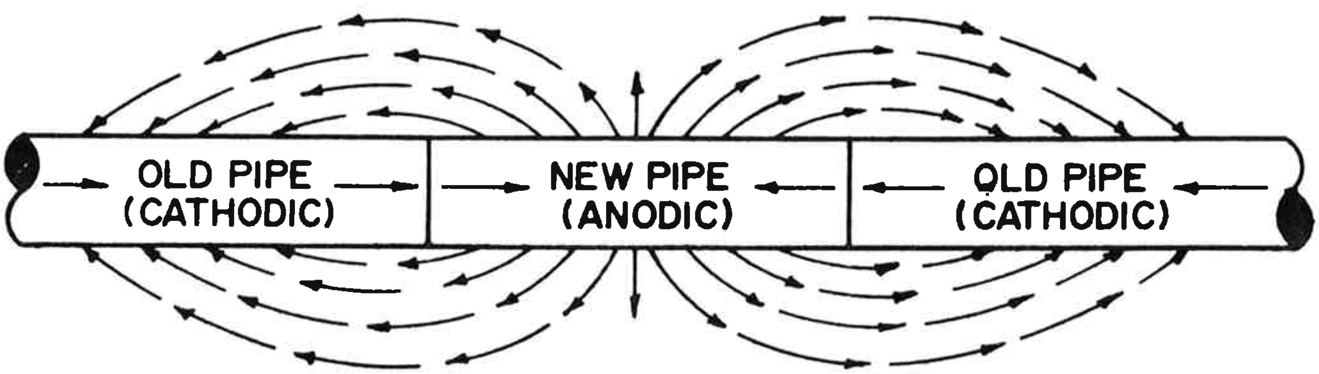
Take the case of a bare steel pipe buried in moist earth. Because of slight differences in metal composition or surface condition, and because of slight differences in the nature of the soil touching the pipe, small potentials or voltages tend to be set up between some areas of the pipe surface and other adjacent areas. This is analogous to the battery action just described. From the more negative areas, as before, current will flow into the soil (which acts as the electrolyte) and through it to the more positive or cathodic areas and back again through the metal of the pipe. At the negative, or anodic area, metal will dissolve. At the adjacent cathodes no corrosion will take place. This accounts for the commonly observed action of pitting; the pits are anodes where the metal is corroding, the unaffected areas around the pits having been acting as cathodes and thus having been protected. Nevertheless, because every anode needs a cathode, the uncorroded areas were necessary to the reaction.

Current is conducted in this case through the moist earth by a stream of hydrogen ions. Where these ions arrive at the cathode areas they are discharged and result in a film of hydrogen. This usually reacts with oxygen dissolved in the soil, and is not evolved as a gas. This little corrosion cell is representative of millions of similar ones on the surface of any pipe. The length of the current path may be anything from a millimeter or smaller to several miles, but the strength of the current is always proportional to the corrosion rate. One ampere, flowing for one year, will dissolve 20 lbs. of steel.



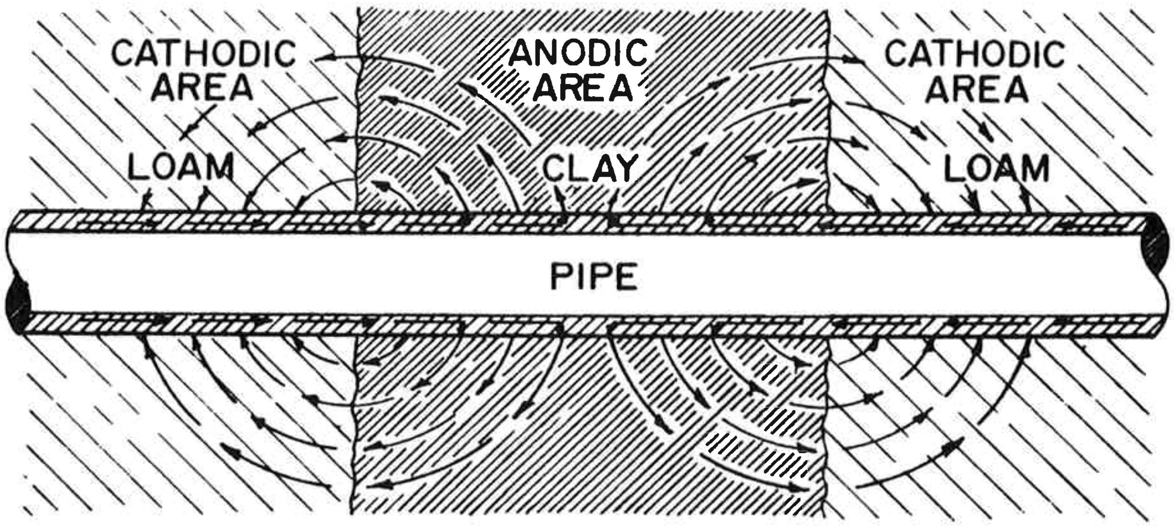
PIT ACTION

Here we see a well advanced corrosion cell in which the anode has corroded to form a pit. The corrosion product has built up over the top of the pit to form a tubercle. This rust deposit is soft and quite permeable, and offers no resistance to the passage of the current through it and, in fact, aggravates the situation. Once a pit is started, the voltage of the corrosion cell goes up and the action is intensified.



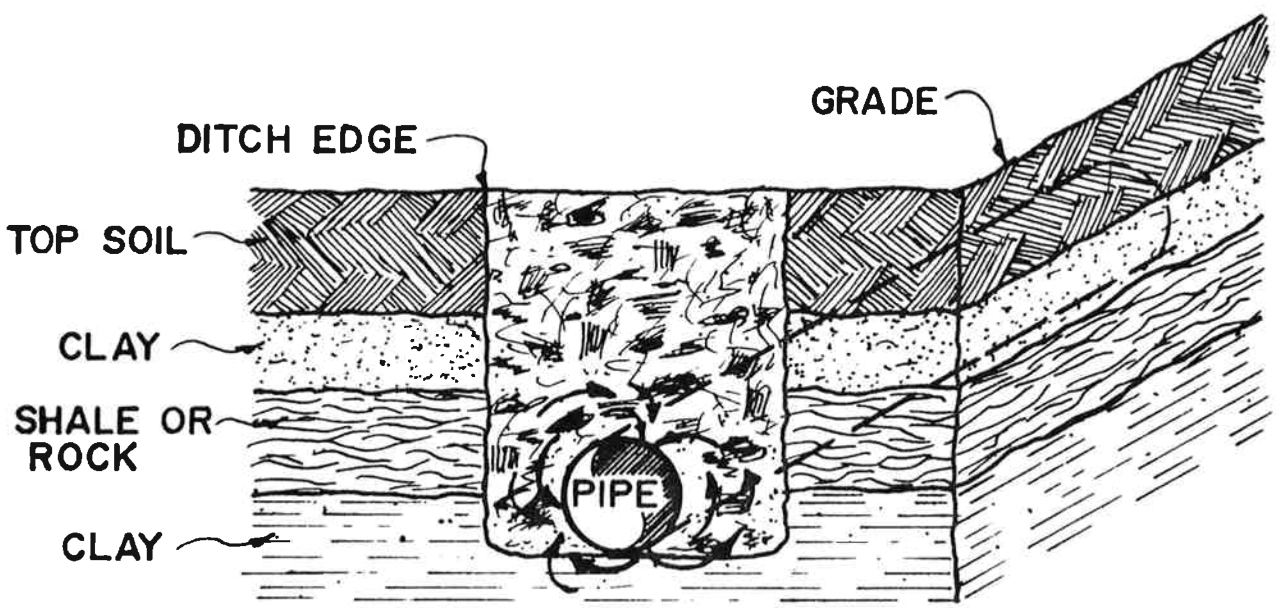
CORROSION DUE TO DISSIMILAR METAL

In the battery just discussed, the voltage was set up by the fact that the anode and cathode were made of different materials. In fact, it is always some difference of metal or soil which causes current flow and its associated corrosion. The greater the difference, the more severe will be the attack. Pipeliners are always saying that pipes these days are not as good as they used to be. The example is often cited of the line that lasted many years until one short section had to be replaced. The new pipe then only lasted a few years before it had to be replaced again. The trouble was not that the new pipe was defective but that in coupling together new and old pipe, a cell of different materials was set up, in which the new clean pipe was strongly anodic to the old rusty pipe, and it corroded as a result of the currents which flowed.



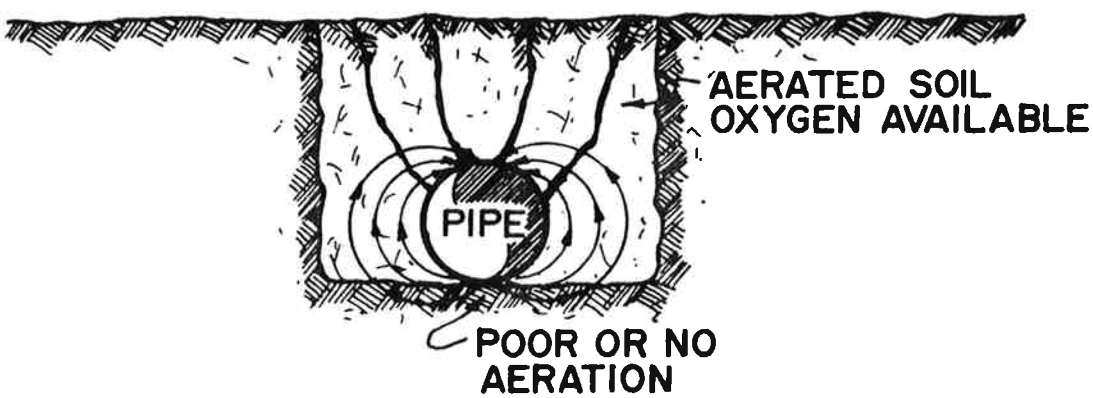
CORROSION CAUSED BY DISSIMILAR SOILS

Differences in the nature of the soil in contact with the pipe can form galvanic cells too. The lighter, more porous soils are most likely to become cathodes. The metal in contact with the more impervious clay will suffer.



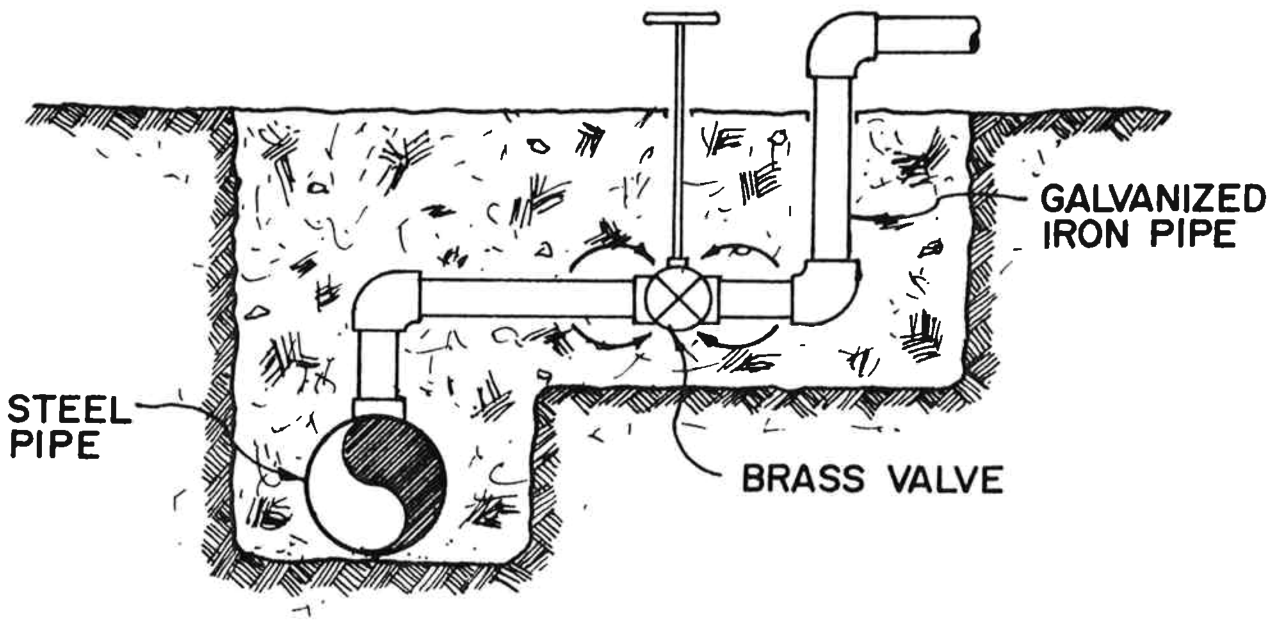
CORROSION CAUSED BY A MIXTURE OF DIFFERENT SOILS

Such a condition often exists when a trench is backfilled with a mixture of lumps of different kinds of soils, as shown.



CORROSION CAUSED BY DIFFERENTIAL AERATION OF SOIL

If one surface of the pipe has more access to oxygen than another surface, a similar cell will be set up. This accounts for a familiar condition when the bottom of the pipe, in contact with undisturbed, poorly aerated soil at the bottom of the trench, is subject to more corrosion than is the top of the pipe, which has an ample oxygen supply through permeation into the loose backfill.



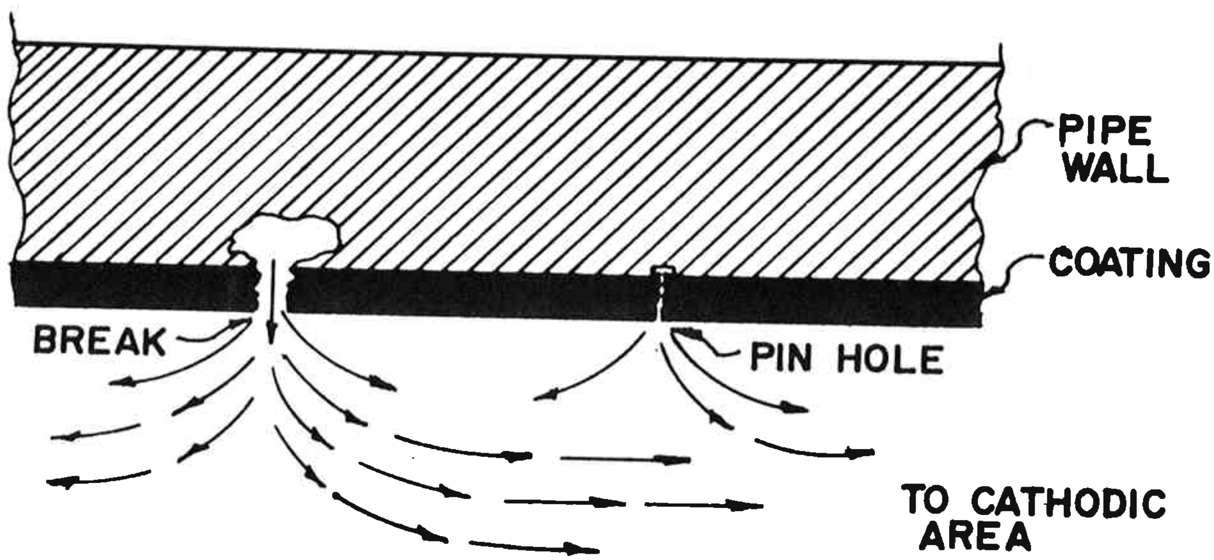
CORROSION DUE TO DISSIMILAR METALS

Corrosion Due to Dissimilar Metals

Most snow making systems consist of steel pipe with water or air hydrants. These hydrants usually consist of a brass valve with galvanized iron piping connected to the steel main. A bi-metallic galvanic cell is always established when two metals in electrical contact with each other are buried adjacent to each other. Taking the case of the snow making hydrant, we have galvanized iron piping connected to a brass valve which in turn is connected to a steel pipeline with galvanized iron pipe. The metallic circuit is this case is the threaded connection between the galvanized iron pipe and the brass valve. The galvanizing on the pipe adjacent to the valve will corrode first. Once the galvanizing is depleted the steel piping will then corrode by the influence of the brass valve which acts as a cathode and, of course, the steel piping would be the anode.

Pipeline Coating

Some manufacturers or suppliers of snow making systems will suggest that you should coat your pipelines and this will prevent corrosion. However, coatings tend to concentrate corrosion at breaks and pinholes in the coating.



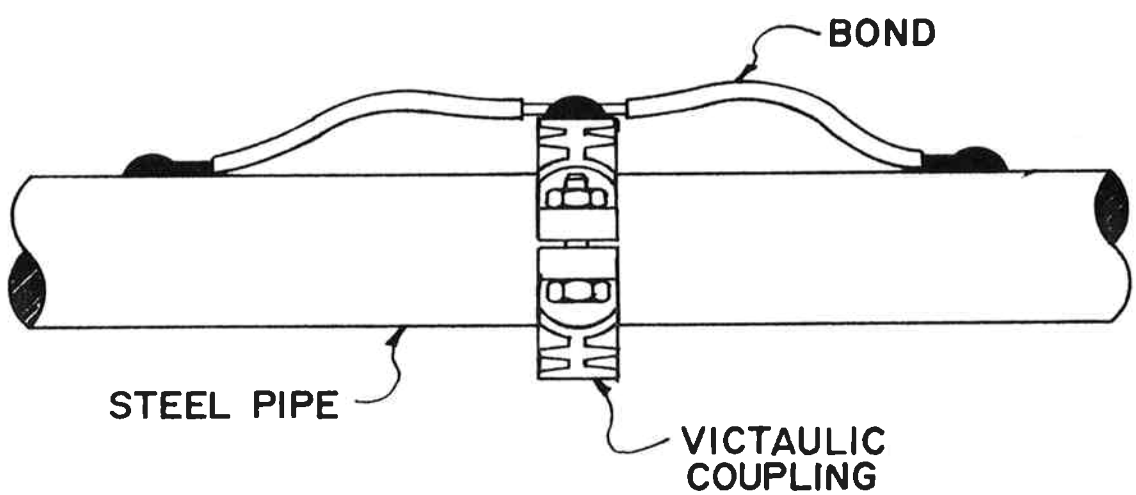
CONCENTRATION OF CORROSION AT BREAKS AND PIN HOLES IN COATING

Concentration of Corrosion at Breaks and Pinholes in Coating

Since for every ampere year of current 20 lbs. of metal are dissolved, the rate of penetration is dependent on the area from which the metal is taken. If the pipe is coated and buried in the soil the coating can in some cases cause more rapid penetration of the pipe because of areas from which the metal can be taken by the corrosion cell are confined to pinholes or cracks in the coating which are anodic to the coated pipe. This is especially important with the thin wall pipe which most operators install for snow making systems, with thicknesses in the order of .156" for 4" dia. and smaller, and .188" for 6" dia. piping. Perforation of the pipe wall can be extremely rapid when the pipe is coated. This, of course, results in a loss of pressure in the system and a wet spot on the hill where the water is escaping.

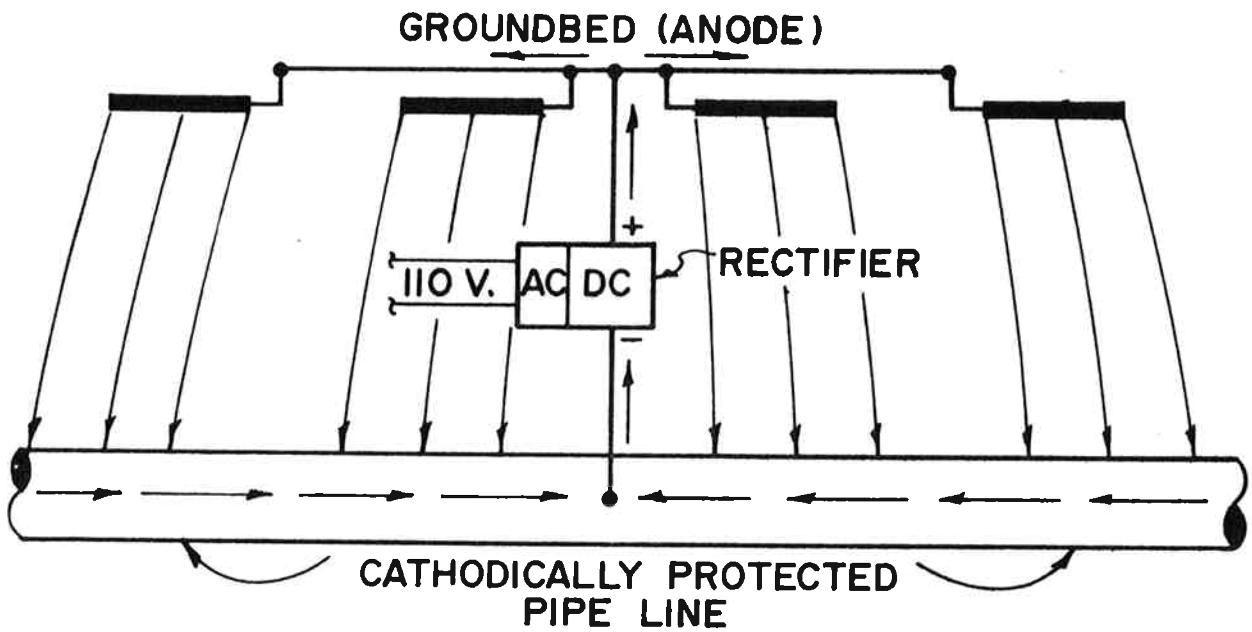
Cathodic Protection

There is, of course, a simple solution to this dilemma. Cathodic protection can protect your pipelines against corrosion from external sources. To reiterate an important maxim - Anodes corrode, cathodes don't. It follows from this that it is only necessary to make a structure sufficiently cathodic to prevent its corrosion. If we pass current from the earth to the pipeline, incoming currents will nullify any outgoing currents from the anodes of local corrosion cells and the pipe receiving current over its whole area will be immune from corrosion. This, of course, soundsoverly simple. Many factors affect the choice of cathodic protection systems such as the resistivity of the soil, whether the pipe is coated or not, and the type of coating, whether or not the pipe can be electrically isolated from other structures. Since a pipeline connected into hydro neutrals requires considerably more current than a pipe that is electrically isolated from hydro neutrals this is an important consideration when designing a cathodic protection system. The amount of copper or brass connected in the system is an important consideration, as well as the electrical integrity of the pipeline. For instance, Victaulic coupled pipelines cannot be cathodically protected unless all of the couplings are bonded over to ensure electrical continuity.



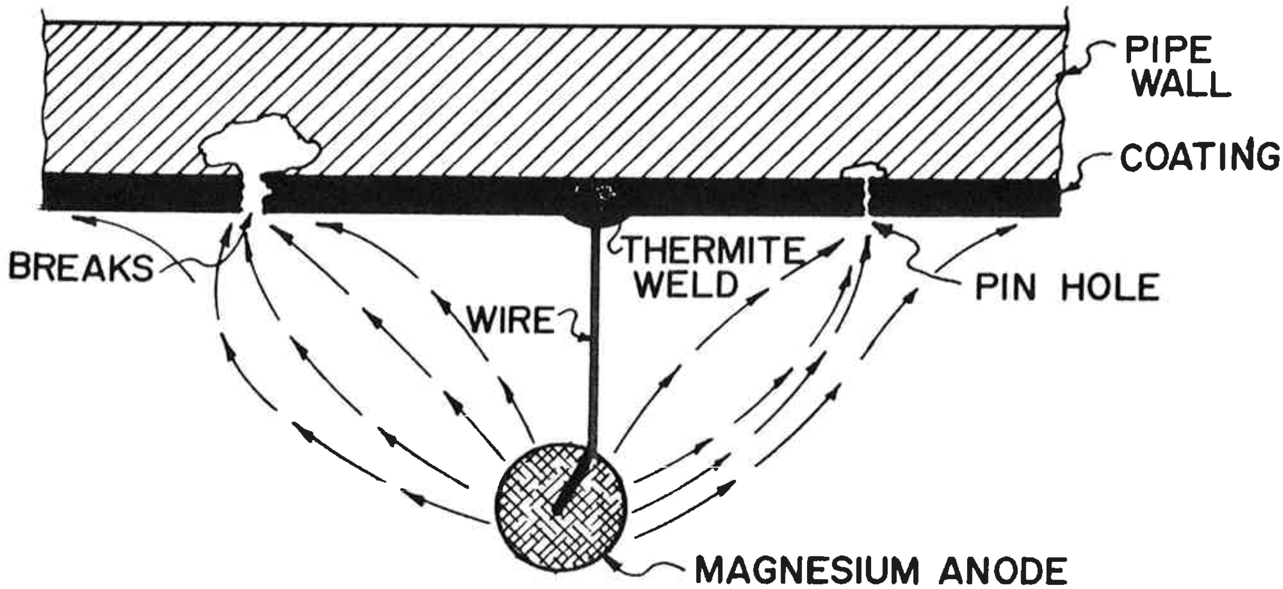
BONDING OF VICTAULIC COUPLINGS

Once the pipeline is known to be electrically continuous then a choice can be made as to whether the pipeline should be protected in an electrically isolated condition, or whether it should be protected with interconnections to other piping systems or hydro neutrals. This will have an effect upon the type of system chosen for cathodic protection, be it sacrificial or powered. These systems describe the source of current which will nullify any currents which exist from local corrosion cells on the pipe. The economics of the system also play an important part. If the piping is to be protected without electrical isolation the choice is usually for a powered system which consists of a rectifier and a groundbed installed some distance from the pipelines.



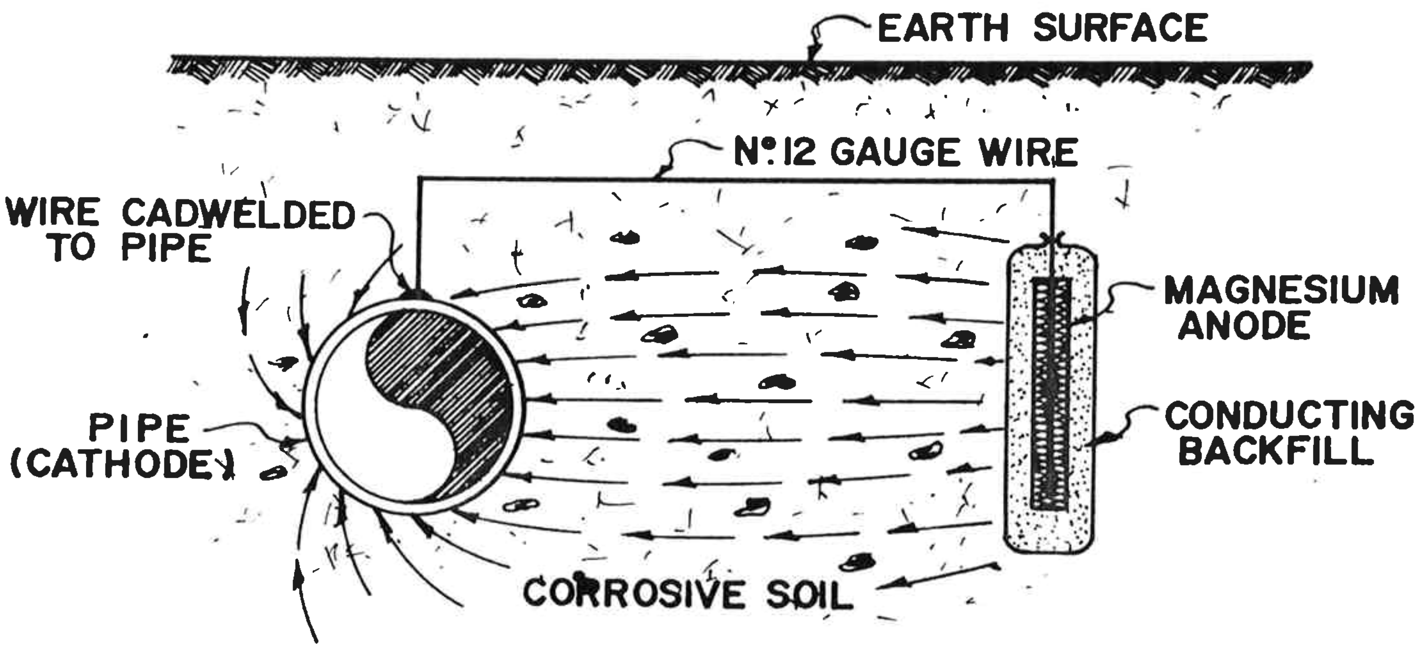
CATHODIC PROTECTION RECTIFIER

The rectifier is powered by the electrical service and is sized to allow sufficient current to protect the pipeline and any other metallic structures in the ground in the vicinity. The current generated by this rectifier flows from the groundbed through the soil circuit to the pipeline. The amount of current required is determined by field tests undertaken on the existing pipeline. The least complicated and maintenance-free form of cathodic protection is the sacrificial system which consists of magnesium anodes attached to the pipeline.



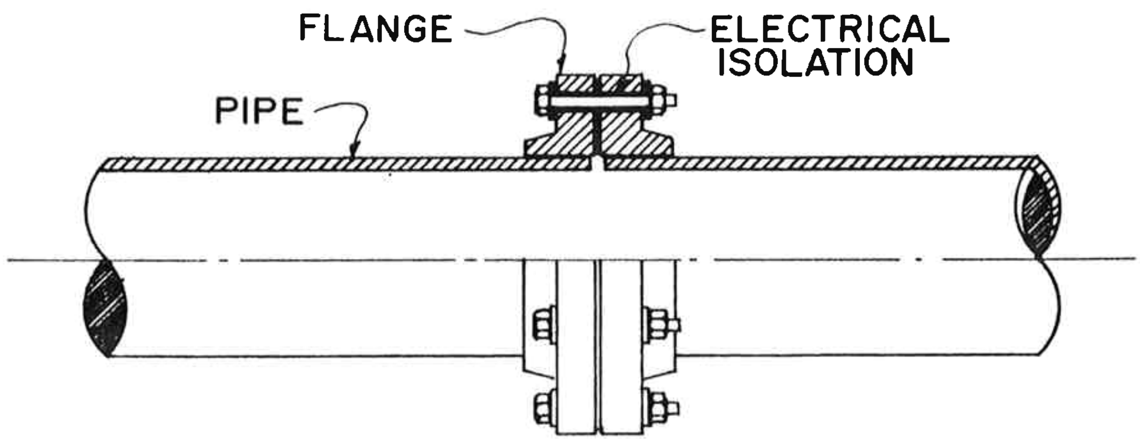
PIPE PROTECTION WITH COATING AND ANODES

However, for this system to be economical the pipeline must be coated. The coating must be of good quality, must be relatively inert and not easily damaged. Typical coatings used on modern piping systems are coal tar enamel, extruded polyethylene, and polyethylene tape. New coatings are coming on the market, such as powdered epoxies and catalytically cured coal tar epoxies.

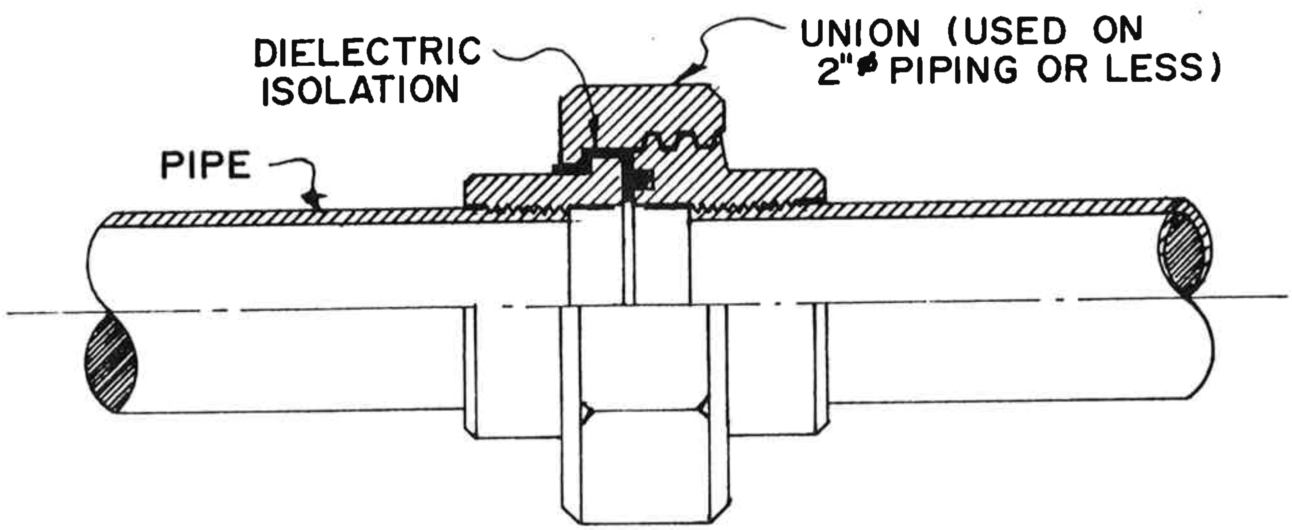


CATHODIC PROTECTION MAGNESIUM ANODES

The sacrificial system is usually used on a new pipeline where the corrosion engineer can have a voice in the design of the snow making system. A specification can then be written for the coating of the pipeline and hydrant systems and the installation of magnesium anodes and necessary test stations, as well as the design of the piping system in the pumphouse, such that the pipes can be easily electrically isolated from other metallic structures.



ELECTRICAL ISOLATION

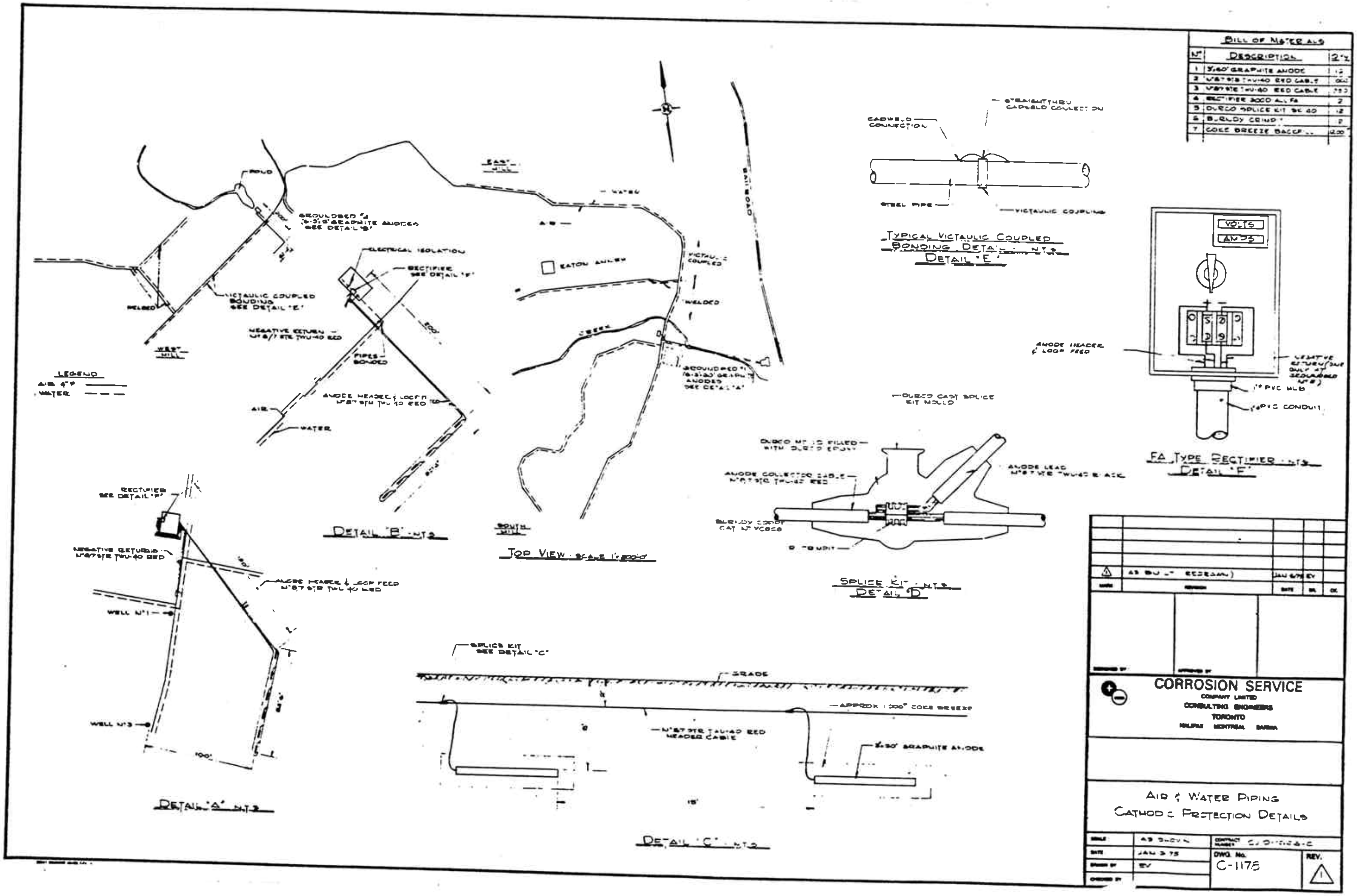


ELECTRICAL ISOLATION

Is Cathodic Protection Expensive?

The price of a cathodic protection system will vary from area to area, depending upon the extent of piping involved, whether or not the piping is electrically isolated and the soil conditions. Typical costs would range from 5¢/ft. to $1.50/ft. of pipe, with the cheapest system being that applied to a coated, electrically isolated pipeline, and the more expensive costs to a bare, non-electrically isolated pipeline. Of course, it is far more expensive to protect 200 or 300 ft. per ft. than it is to protect several miles of pipe per ft., since travelling, accommodation costs, and labour costs must be taken into consideration. One should consider the cost of cathodic protection in comparison to the cost of having to dig up a pipeline in the middle of winter, in the middle of your ski hill to effect a repair at a corrosion leak. Not only do you have to contend with frost and damage to the ski run but you have to consider the downtime of your snow making system while you effect repair. Cathodic protection is a tried, proven method of corrosion control of buried pipelines.

In summation, cathodic protection can be compared to birth control, you measure the results by what doesn't happen.


BILL OF MATERIALS
DESCRIPTION
GRAPHITE ANODE
RECTIFIER
SPLICE KIT
COKE BREEZE BACKF...
TYPICAL VICTAULIC COUPLED BONDING DETAIL - NTS
DETAIL "E"
CADWELD CONNECTION
STRAIGHT THRU CADWELD CONNECTION
STEEL PIPE
VICTAULIC COUPLING
VOLTS
AMPS
ANODE HEADER & LOOP FEED
1" PVC HUB
1" PVC CONDUIT
FA TYPE RECTIFIER - NTS
DETAIL "F"
POND
EAST MILL
WATER
AIR
RAILROAD
EATON ANNEX
VICTAULIC COUPLED
WELDED
CREEK
ELECTRICAL ISOLATION
RECTIFIER SEE DETAIL "F"
VICTAULIC COUPLED BONDING SEE DETAIL "E"
WELDED
WEST MILL
LEGEND
AIR
WATER
PIPES BONDED
DETAIL "B" - NTS
SOUTH MILL
TOP VIEW
SPLICE KIT - NTS
DETAIL "D"
ANODE LEAD
DETAIL "A" - NTS
WELL No 1
WELL No 3
100'
SPLICE KIT SEE DETAIL "C"
GRADE
GRAPHITE ANODE
DETAIL "C" - NTS
CORROSION SERVICE
COMPANY LIMITED
CONSULTING ENGINEERS
TORONTO
HALIFAX MONTREAL SARNIA
AIR & WATER PIPING
CATHODIC PROTECTION DETAILS
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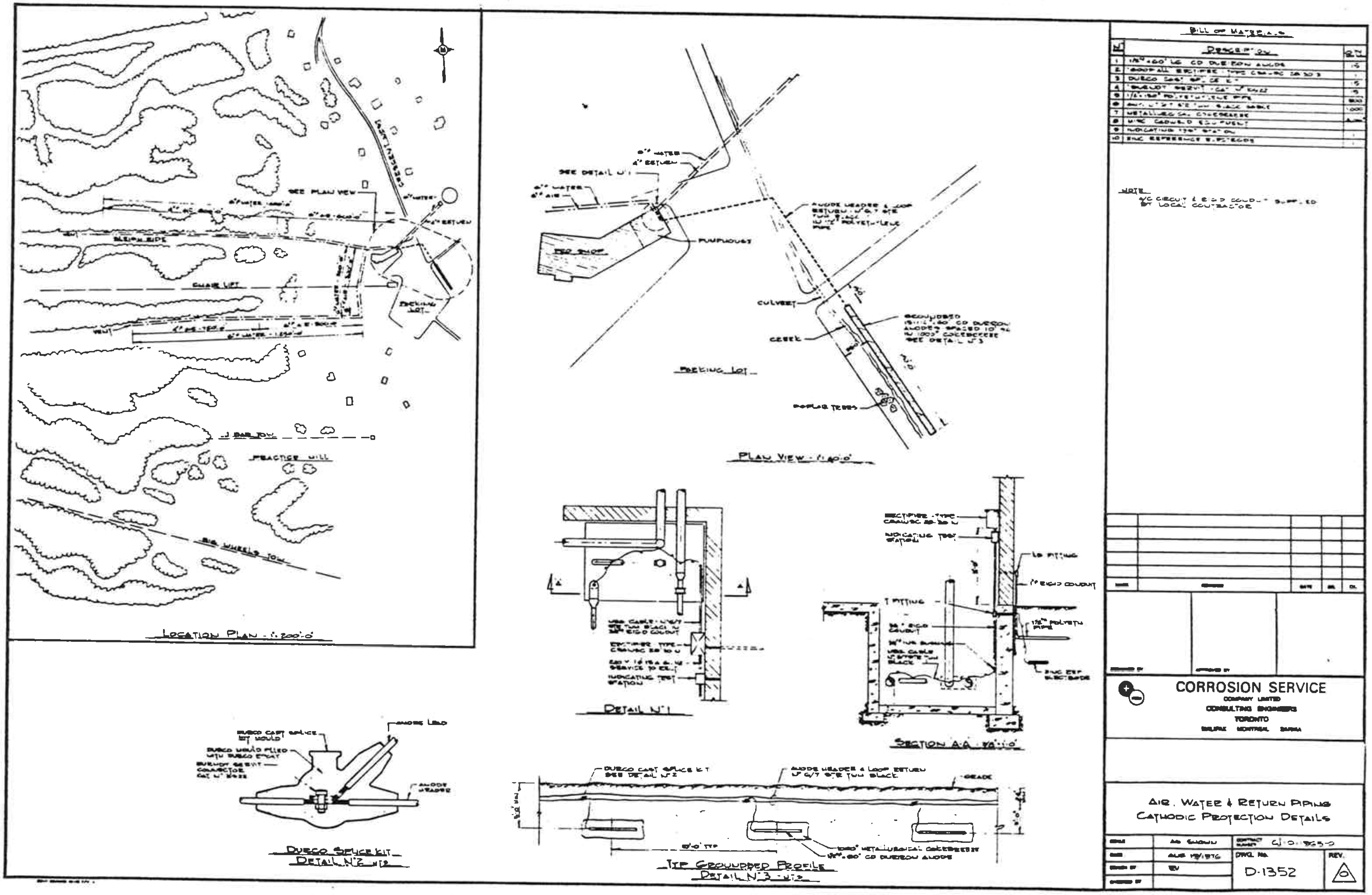
LOCATION PLAN - 1"=200'-0"
PLAN VIEW
PARKING LOT
PUMPHOUSE
CULVERT
CREEK
POPLAR TREES
CHAIR LIFT
PRACTICE HILL
BIG WHEELS TOW
DETAIL N°1
SECTION A-A
DURCO SPLICE KIT DETAIL N°2
TYP. GROUNDBED PROFILE DETAIL N°3
BILL OF MATERIALS
CORROSION SERVICE
COMPANY LIMITED
CONSULTING ENGINEERS
TORONTO
HALIFAX MONTREAL SARNIA
AIR, WATER & RETURN PIPING
CATHODIC PROTECTION DETAILS
AS SHOWN
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