soil, or where concrete has been used as a base, in contact with this. The water found in such soils (or concrete) usually contains salts, acids, etc., sufficient to make it capable of electrolytic conduction; hence either the wet concrete or wet soil is capable under ordinary conditions of conducting electric currents. Current from the return rails that flows or leaks into the soil or concrete must find its way back to the power-house through some underground path. In doing so the current obeys the law of divided circuits, flowing through all possible paths in parallel, the strength in each being inversely proportional to its resistance. Underground water piping systems readily offered themselves as convenient conductors of these stray currents, especially where the rails cross, or parallel in close proximity the pipe. In general, these currents flow along the pipe until they reach the neighborhood of the power house, and at the nearest point to this leave the pipe, return through the soil to the rails, and thus back to the negative terminal of the generator. Where the current leaves the pipe and flows back to the rails the pipe serves as the anode, the soil as the electrolyte, and the rails as the cathode. These currents do no harm to the pipe except where they leave it, and at such points the pipe is corroded or eaten away. The extent of corrosion, or amount of metal destroyed is in keeping with Faraday's law, which holds that chemical decomposition occurring at the electrodes is directly proportional to the current flowing, the duration of flow and the chemical equivalent weights of the substances. The destruction of the metal is independent of voltage, except the determining effect of this on current flowing.

In addition to the damage occurring in the locality of the power house—which is by far the greater and more serious source of trouble—the pipe is also affected at other points where for certain reasons currents leave the pipe, either to shunt around some high resistance section or to return to the rails because of favorable soil conditions and possible close proximity of the tracks. Particularly in the case of cast iron, where there is a more frequent possibility of some lengths of pipe being of unusual high resistance, or the lead joints are so made that the pipes themselves are not in direct contact, the current flowing sometimes shunts around such high resistance pipes or joints. However, this is really an advantage rather than a disadvantage, because it exerts a strong tendency to keep the total current low, causing, as it does from time to time, a portion of what would be final accumulated current to leave the pipe and seek some other path, such as the rails, back to the power house. Obviously, in general, under these conditions the total current leaving the pipes at the power house is small—much smaller than the accumulated current would have been had there been no loss or leakage as here described. Wherever the pipe lines parallel the rails and pass through unusually wet soil there is more danger of serious trouble, such conditions lending themselves readily to the passage of current to or from the pipe or rails.

Under similar conditions with currents of equal strength flowing through iron pipes, the amount of metal destroyed is the same, whether the pipe is steel, wrought or cast iron. However, due to its inherent qualities and peculiar metallic structure, the resistance offered to the flow of electricity by cast iron is, roughly, ten times as great as steel or wrought iron, and the ordinary lead joints employed with cast iron increase this resistance materially, thus reducing proportionately the current flowing, which makes the possibility of electrolysis in the case of cast iron approximately one-twelfth what it would be for the other two kinds of pipe mentioned. It should also be borne in mind that in practice cast-iron pipe has a metal thickness about four times that of wrought iron or steel, which proportionately delays the ultimate total destruction in the case of this class of pipe.

If pipe is of steel or wrought iron, results of electrolysis are seen in pits, these finally extending through the plate. Where the current leaves such pipe the metal is converted into iron oxide, which is frequently noticeable in surrounding soil. If the pipe be of cast iron, the oxides formed often are still held in position by the graphite, and the external appearance of the pipe remains unaffected. When the pipe has been entirely eaten through the mass is about the hardness of pencil lead and collapses under an ordinary hammer stroke, yet a pipe in this condition, if the soil is rather tightly packed about it, may remain without leaking for a considerable period. It is frequently necessary to make a direct physical examination of a pipe and subject it to a hammer test to determine if it has been attacked by electrolysis. So far, we have dealt only with trouble in the mains and distribution system proper. However, while less serious, probably the greater percentage of damage actually occurs in the service pipes, because these frequently pass under the car lines close to the rails, and the pipes, being relatively thin, are quickly pierced. Investigation made in about fifty cities brought out the fact that, roughly, 75 per cent. of the trouble experienced occurred in the service pipes, lead, wrought iron or steel, all being readily affected. Besides the damage to the service pipes themselves, stray electric currents flowing on these may occasionally reach the steel structure of buildings, causing electrolysis to attack the steel, but seldom to any serious extent. Under certain unusual conditions, current flowing on these service pipes may be sufficient to raise them to a temperature approximating red-heat, and in this way cause fires. In some cases of gas pipes explosions have been brought about. However, such occurrences are undoubtedly very rare at the present time, and there seems no good reason to anticipate any increase in this hazard.

Electrolysis from Local Action (Self-Corrosion)

In the preceding section it has been the intention to deal only with the effects of electrolysis due to stray currents, or what is usually spoken of as "anodic corrosion" —that is, action when the pipe serves as the anode, corrosion taking place only where current flows from the pipe to other conductors. Now, in addition to this form of electrolysis, we have what is termed "self-corrosion"—that is, electrolysis by local galvanic action. This is termed "self-corrosion," for the reason that the current originates on the metal itself, and is due in the case of pipe to the impurities of the metal or the presence of carbon or coke in the surrounding earth, or both. Salts and acids in moist soil increase this action. Small pieces of coke or carbon in wet soil in contact with the pipe, even if no physical differences between adjacent parts of the metal exists, will bring about local action, because a difference of potential will exist between the carbon and the iron, which will cause a current to flow from the pipe to the carbon. The potential difference existing under such conditions is approximately one-half a volt—causing a sufficient flow of current to bring about rapid deterioration.

An instance of this kind came to the writer's attention where a large coated steel pipe passing through a cinder bed tailed completely in a short time, the metal structure