Dec. 1, 1942. A. WESLEY 2,303,778

SOIL PIPE

Filed March 4, 1941

Fig. 1.

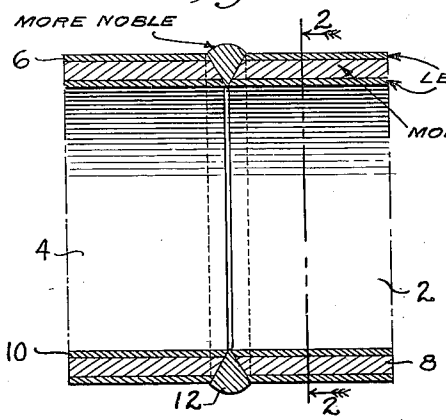


Fig. 2.

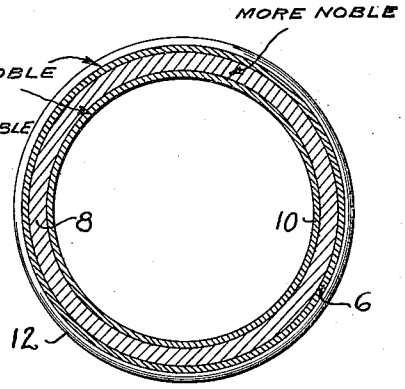


Fig. 3.

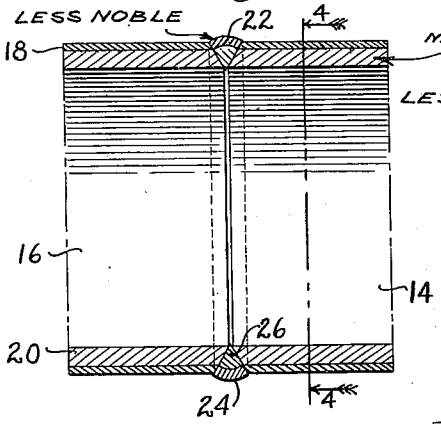


Fig. 4.

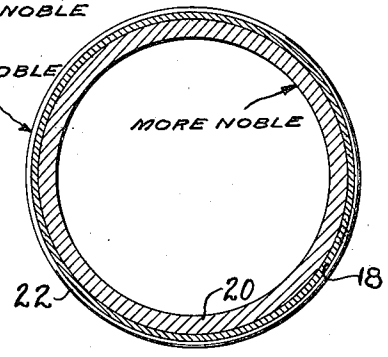
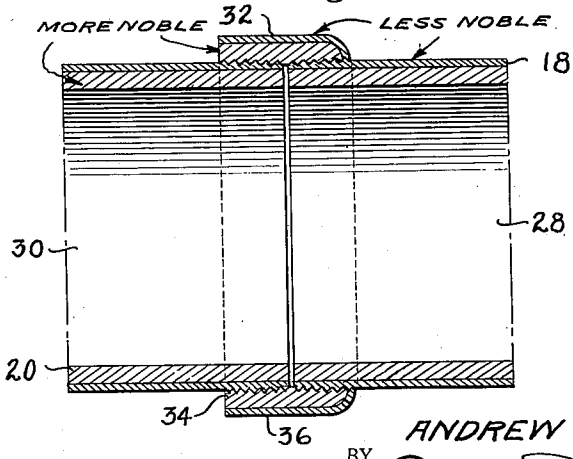


Fig. 5.



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SOIL PIPE

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4 Claims. (Cl. 138—64)

The present invention relates to a soil pipe which resists penetration by corrosion, and, more particularly, to a soil pipe made of composite ferrous layers having a critical relation of potential differences between the exposed layer and the under layer in which the less noble layer is exposed to the corrosive material.

It is well known that metal pipes buried in soil are subject to corrosion which proceeds non-uniformly over the exposed surfaces. The researches of the Underground Corrosion Division of the National Bureau of Standards, for example, have shown that in the corrosion of iron and steel buried in the soil, the rate of deepest pitting in most soils is 7 to 10 times greater than the penetration by general corrosion. Non-uniform eating away of the metal causes far greater economic loss than would result from uniform corrosion over the entire exposed area even though the weight of the metal lost in the case of uniform attack is greater than in the case of localized corrosion. Penetrating pit formation resulting from non-uniform attack materially shortens the useful life of a pipe and enormous outlays must be made in the maintenance of long pipe lines for conveying water, gas, oil, gasoline, etc., where it is the occurrence of perforation of the pipe by the deepest pit rather than the slow general corrosion which determines when a length of pipe must be removed.

It has been proposed to construct pipes of alloy steels but experience proved that any increase in life due to enhanced resistance of such steels to corrosion was too small to be economically justifiable. The alloy structural steels, moreover, were susceptible to non-uniform corrosion to much the same relative degree as plain carbon steels.

It has also been proposed to construct pipes of coated metals having a thin layer of metal more noble than iron or steel which was exposed to soil or other corroding agent. Unfortunately, such composite metals suffered from the disadvantage that their usefulness depended upon the integrity of the corrosion resistant layer because if there were discontinuities in the coating metal initially, or if discontinuities developed in service, so that the base or foundation metal of iron or steel was exposed to the action of a corroding medium, the attack proceeded at such points in the foundation metal even faster than would have occurred in the absence of the more noble coating. Insidious in nature, the extent of the attack in the base metal was often hidden behind the layer of exposed metal in which a mere pinhole was perceptible whereas the base structural metal was eaten away over a large area due to the electrolytic relations of the two metals. Inasmuch as the pipes were almost entirely dependent upon the base structural metal for strength, detrimental and dangerous weakening of the structure resulted from such non-uniform corrosion, and in some instances failures occurred and of course leakage developed. The cost of steel coated with more noble metal was very high compared with plain carbon steel and was practically prohibitive commercially.

The development of a satisfactory material of construction for soil pipes has been a major problem facing the art.

I have discovered that pipes possessing adequate strength and satisfactory resistance to penetrating pit corrosion may be constructed by using composite ferrous plates provided the individual layers of the composite plate are thick enough to contribute appreciably to the strength of the structure and the layer exposed to the corroding medium is anodic with respect to the underlying layer.

It is an object of the present invention to provide a pipe which will be resistant to perforation by localized corrosion.

It is another object of the present invention to provide composite ferrous pipes comprising two or three layers of metal having different electrochemical potentials and the less noble metal is exposed to the corroding agent or agents.

It is a further object of the invention to provide pipes made of composite steel plates resistant to penetration by localized corrosion in which the individual layers of steel forming the composite pipe are of substantial thickness, each layer contributing appreciably to the strength of the structure.

It is also within the contemplation of the invention to provide pipes in which those parts that are exposed to corrosion from only one side, e. g., from the soil, are made of composite metal having two layers of ferrous metal with different electrochemical potentials, the less noble of the two being exposed to the pitting corrosive.

The invention likewise contemplates the provision of pipes in which those parts that are exposed to pit corrosion from both sides are made of composite metal having three structural layers of ferrous metal, the exposed layers being less noble than the central layer.

Other objects and advantages of the present invention will become apparent from the following description taken in conjunction with the accompanying drawing in which:

Fig. 1 represents a fragmentary longitudinal section of a three layer pipe line adjacent to a welded joint;

Fig. 2 is a cross section of the pipe shown in Fig. 1 taken along the line 2—2;

Fig. 3 illustrates a fragmentary longitudinal section of a two layer pipe line adjacent to a welded joint;

Fig. 4 is a cross section of the pipe illustrated in Fig. 3 taken along the line 4—4; and

Fig. 5 depicts a fragmentary longitudinal section of a two layer pipe line adjacent to a coupled joint.

Generally speaking, the invention comprises pipes made of composite structural plates of ferrous metal, preferably steel, the layers of which are sufficiently thick to contribute appreciably to the strength of the structure and which have different electrochemical potentials. The layers are so arranged that the less noble layer is exposed to the pitting corrosive.

Referring now more particularly to Figs. 1 and 2 of the drawing, it will be seen that the fragment of the pipe line illustrated includes two lengths of pipe designated by reference numerals 2 and 4, each of which is made of a composite plate comprising an outer layer 6, an intermediate layer 8 and an inner layer 10. The two lengths 2 and 4 are joined together by a weld 12. The exposed layers 6 and 10 are of appreciable thickness and strength and are not to be confused with thin, weak protective layers such as galvanized coatings, electro-deposited coatings, and the like. Layers 6 and 10 are respectively exposed in use to the corrosive action of the soil and the contents, such as salt water contaminated mixtures, which attack metal non-uniformly with the production of corrosion pits. In accordance with the principles of the present invention, layers 6 and 10 are made of steel less noble than layer 8. For example, in making a pipe having a wall thickness of about 0.3 inch layer 8 may be made of an alloy steel about 0.16 inch thick containing about 1% of copper and about 2% of nickel, and layers 6 and 10 may be plain carbon steel about 0.07 inch thick. Similarly, layer 8 may be steel of the S. A. E. 2515 type, an alloy steel containing about 5% of nickel, and layers 6 and 10 may be a plain carbon steel, the thickness of the layers again being about 0.16 inch for layer 8 and 0.07 inch for layers 6 and 10. In both cases, the layers 6 and 10 are anodic with respect to layer 8, i. e., layers 6 and 10 are less noble than layer 8. All layers, moreover, have relatively high physical properties and are sufficiently thick to contribute substantially to the strength of the plates making up the walls of the pipes. The layers 6 and 10 do not consist of a mere thin coating without structural strength, as in the prior art pipes of galvanized or coated steel sheets, but is to be considered as a structural element of the combination. This is commercially practicable in pipes embodying the present invention because the lyers are composed of relatively inexpensive steels having good mechanical properties. Further and important advantages of pipes embodying the present invention are that there is no danger that the layers 6 and 10 will crack or peel off even under severe physical shocks in handling, joining, etc., that corrosive attack is confined to the layers 6 and 10, until they have been substantially all eaten away even though the layer 8 may become exposed to the corroding medium through pits, perforations and the like in the layer 6 or 10, and that the true condition of the pipe may be readily determined by visual inspection since hidden corrosion cannot occur in composite pipes embodying the present invention.

It will be observed from the foregoing that the structural layers of the pipes embodying the present invention are arranged opposite to that of the prior art clad steel structures in which the more resistant layer had been exposed to the corrosive medium, whether soil or fluid. The prior art arrangement was, of course, the natural and reasonable way to attack the problem in the light of existing knowledge and experience with the protection of steel against atmospheric and many other types of corrosion. Soil pipes, however, are subject to the foregoing peculiar and special corrosive conditions which lead to pit formation, and under these special and unique circumstances a cladding of more noble metal deters the attack on the under layer only a relatively short time, i. e., only until it is perforated by pits, after which the attack on the base metal proceeds at an accelerated rate due to the unfavorable relationship of electrochemical potentials of the two layers. By reversing the potentials of the exposed and under layers, and by making both of substantial thickness, the surprising discovery has been made that total life of a pipe line is increased many times. This new and surprising result is obtained, moreover, with cheaper materials which are easily produced in structural shapes and plates and readily fabricated into pipes and pipe lines.

While the mechanism of pit corrosion of duplex pipes having layers of different nobility is perhaps not entirely clear, a probably theoretical explanation is that when a layer of protective metal, e. g., a metal more noble than a base layer of carbon steel, was exposed to a corroding medium and the attack proceeded non-uniformly, as it normally does, pits began to form in the protective metal which eventually reached the less noble layer, e. g., plain carbon steel. As soon as this layer was exposed, localized corrosion proceeded rapidly at these points until both layers were perforated. The two metals formed, in effect, an electric cell in which the base metal was the anode, the protective metal the cathode and the corrosive medium the electrolyte. The base metal was thus anodically corroded at a relatively rapid rate depending upon the electrolyte, the difference in the potentials of the two metals, etc., as those skilled in the art will readily understand. On the other hand, when the less noble layer, e. g., the plain carbon layer, is exposed to the corroding medium as in pipe lines constructed in accordance with the present invention and the attack proceeds non-uniformly, pits begin to form just as above and eventually reach the more noble layer, e. g., the above mentioned copper-nickel or nickel steel, but further penetration is arrested as substantially no corrosion of the under layer of more noble steel can occur until practically all of the outer layer of less noble steel has been corroded away. In other words, instead of pit formation proceeding at an accelerated rate as soon as the outer layer is perforated, as in the prior art structures where the more noble layer was first exposed to the corrodant, it substantially ceases in structures embodying the present invention where the less noble layer is first exposed.

The pipe line illustrated in Fig. 1 is adapted for use in situations where the metal is exposed in use to non-uniform corrosion both by the soil and the contents of the pipe line. Where

the contents are not particularly corrosive or do not attack non-uniformly, a pipe line constructed as illustrated in Figs. 3 and 4 may be employed. The two pipes 14 and 16 are made of two structural layers 18 and 20, preferably of approximately equal thickness although the ratio of the thicknesses is not critical so long as both layers are of sufficient thickness to contribute structurally and substantially to the strength of the pipe. The desirable ratios of thicknesses between the more noble and less noble layers of the pipe will depend upon relative costs, corrosion rates, the stress imposed, and other practical limitations. Generally speaking, the less noble material in duplex pipe will constitute from about ⅓ to ⅔ of the total thickness. For example, in making a pipe having a wall thickness of about ⅜ inch, the outer layer may be made of mild steel about 1/8 inch thick and the inner layer may be made of low alloy steel, such as S. A. E. 2515, of a solution potential more noble than mild steel, also about 1/8 inch thick. Both layers contribute to the strength of the pipe and when the deepest pits penetrate the mild steel layer the more noble alloy steel is exposed but further penetration at that point is arrested or greatly delayed by galvanic protection of the alloy steel due to its contact with the less noble mild steel layer.

The lengths of composite pipe are joined together at their juxtaposed edges or ends to form the pipe line. As shown in Fig. 3, the length of pipe may be joined by welding and in this instance the weld has been illustrated as comprising an outer bead or layer 24 of material substantially corresponding in composition or nobility to the outer layer 18 overlaid on a layer of weld metal 26 having a composition approximately the same as, or at least the order of nobility as the more noble layer 20 of the pipe. It will be apparent to those skilled in the art that in welding together three layer pipes of the type illustrated in Fig. 1 a three layer composite weld may be utilized in which the layers of the weld correspond substantially in order of nobility or composition to the layers of the joined pipes. Ordinarily, however, satisfactory results may be obtained in practice using a welding rod corresponding substantially in analysis or order of nobility to the more noble layer of the pipe.

Other types of joints may be used for connecting the lengths of pipe together to form a pipe line. For example, I have illustrated in Fig. 5 a screwed joint suitable for connecting two lengths of pipe similar to those illustrated in Fig. 3. These lengths, which are designated 28 and 30 are provided with screw threads at their ends and they are connected together by a sleeve coupling 32 in the usual manner. The coupling 32 is preferably made of composite metal having an under layer 34 and an outer layer 36 corresponding to the composite pipes which are to be joined together. The exposed layer 36 is made of the less noble metal. Where the corrosive conditions are not severe satisfactory results may be had where the more noble metal 34 is exposed, as shown at the left end of the coupling. The exposure of the more noble metal 34 will cause some acceleration of the corrosion of the adjacent outer surface of the pipe and where it is desired to avoid this, the end of the coupling may be spun over or otherwise covered with a layer of the less noble metal as illustrated at the right end of the coupling.

Other types of joints, for example, flanged couplings, packed and wiped joints may also be used and these types of joints involve no deviation from standard practice except that in the case of flanged couplings, the flanges and bolts must be made thick enough to last as long as the expected life of the pipe line.

It is essential to the success of my invention that the potential difference between the exposed and the under layer be at least large enough to give effective protection. A 2% nickel steel coupled to plain carbon steel gives an adequate potential difference as do various of the copper-nickel steels when coupled to carbon steels. On the other hand, the potential difference should not be so large as to result in excessive corrosion rates where a portion of the more noble layer is exposed. Large potential differences are not only detrimental from a corrosion standpoint but entail the use of larger percentages of alloying elements and hence increase the cost. In general, low alloy steels appear adequate to provide the necessary difference in nobility. In electrochemical potential tests in which plain carbon steel was coupled with 1% copper-2% nickel steel, the potential difference was about 0.08 volt in a 3% sodium chloride solution. Correspondingly, the potential difference when the 5% nickel steel was coupled with plain carbon steel of the same analysis in the same solution amounted to about 0.11 volt. In general, it is preferable to maintain a potential difference between the layers of more noble and less noble steels employed within the range of about 0.07 volt to about 0.15 volt, as determined by this test, and for practical purposes the potential difference should never exceed about 0.2 volt.

It is evident that under the more important soil corrosion conditions the absolute potentials exhibited by different ferrous alloys may cover a considerable range, the important requirement being that the ferrous alloys selected for the surface and underlying layer exhibit sufficient difference in their potentials to arrest the progress of pits upon the exposure of the underlying layer, as just described.

For most purposes a plain carbon steel is entirely satisfactory for the less noble component and is the cheapest material for the purpose, although it is possible that steels even less noble than carbon steel could be used. Low alloy steels containing nickel or nickel and copper would ordinarily be employed for the more noble layer, as nickel and copper tend to increase the nobility. Production difficulties limit the amount of copper that can be present in the absence of nickel to levels which are scarcely adequate to provide sufficient nobility to be highly effective as the more noble layer when coupled with plain carbon steel. Other elements such as cobalt, molybdenum and the like which render iron more noble may also be employed in the more noble layer but are rather expensive and, except in instances where their effect upon other properties is of value, they appear less desirable than nickel or copper and nickel.

The present invention contemplates the use of two steels or cast irons of different alloy content or structure for the more noble and less noble layers respectively. Thus, where high mechanical properties are desired, two low alloy steels differing in composition to provide the essential difference in nobility could be employed; for instance, a low copper steel could be employed for the

outer, less noble layer or layers and a nickel or copper-nickel steel of higher alloy content than required when carbon steel is employed for the less noble element, could be employed for the more noble layer, the relative amounts of alloying metals being selected to produce the desired difference of potential between about 0.07 and 0.2 volt, as above described.

The composite pipes of the present invention may be manufactured in any commercial manner. For example, composite pipes may be manufactured by assembling clean close-fitting seamless tubes of each of the different metals or alloys desired in the composite pipe and working them, e. g., by drawing, to produce at least good mechanical and electrical contact. Preferably tubes of larger diameter than the final desired size are assembled and hot rolled and/or hot drawn to the desired dimensions. This treatment involving the simultaneous application of heat and pressure results in thorough bonding of the layers of the composite pipe. Fitting by shrinking is another method that may be employed in assembling concentric tubes for direct use or for reduction to smaller size. Composite pipes may also be produced by casting directly to finished size, for example, by centrifugal casting. By properly choosing the composition of the layers making up the composite pipe, the pipe may be made of cast iron or steel or a combination of both, e. g., an outer layer of less noble steel lined with a casting of a more noble cast iron or steel, in accordance with the principles of the present invention which have been set forth herein.

Composite pipes embodying the present invention may also be made, if desired, from composite skelp by welding the longitudinal seams in the manner hereinabove disclosed for the transverse seams 12 and 22, for example. The composite plates from which the skelp is produced may be made by positioning a slab of low carbon steel having a cleaned surface at one side of a mold with the cleaned surface exposed to the casting cavity remaining at the other side of the mold into which the nickel, nickel-copper, or other alloy steel that is to form the more noble layer is then cast to form a composite ingot. A satisfactory bond between the low carbon steel and the alloy steel is formed in this manner and the composite ingot may be rolled into composite plate by the use of conventional equipment, as those skilled in the art will readily understand. It will be understood by those skilled in the art that the preformed slab that is positioned in the mold could be the alloy steel against which the low carbon steel is cast. Similarly, if a three layer plate is desired, a slab of the alloy steel which has been cleaned on both sides may be positioned at the center of a mold with casting cavities at either side into which low carbon steel may be poured to form a three layer composite ingot; or two slabs of the low carbon steel could be placed at the sides of the mold leaving a casting cavity between them into which the alloy steel is cast to form a three layer composite ingot. The three layer composite ingot may be rolled into three layer composite plate in the conventional manner, as those skilled in the art will readily understand. Instead of casting one of the metals against a preformed slab of the other in the aforesaid manner, the composite plates may be fabricated by welding plates of the desired composition together. A well known method that may be used comprises placing the plates to be welded in superimposed relation with the juxtaposed faces of the plates suitably cleaned and prepared for welding, heating the superimposed plates to welding temperatures and then passing the heated plates between rolls to effect intimate contact between the juxtaposed faces of the plates whereby welding takes place over the entire contacting areas of the plates and a composite plate is produced. The fact that steels of essentially similar working characteristics can be employed and chromium need not be present avoids numerous troubles which have been involved in the production of previously known duplex materials. The foregoing methods of producing the composite pipes or plates to be used in making pipes embodying the present invention are merely illustrative and are not to be construed as the only available methods. Any method whereby composite pipes of the foregoing kind may be produced may be employed to manufacture the composite pipes to be used in the construction of pipe lines embodying the present invention, as those skilled in the art will readily understand.

It will be seen that a pipe line constructed in accordance with the present invention has a number of important practical and commercial advantages. The composite pipes can be made of low alloy steels which are easily bonded and welded together and readily worked to shape. The layers are of appreciable thickness so that there is no danger of peeling or rupture of a coating and each layer contributes structurally to the strength of the pipe. Even with inexpensive low alloy steels, highly satisfactory resistance to localized corrosion is obtained.

It should be noted that in this description and in certain of the claims, the terms "low alloy ferrous metal," "low alloy iron," and "low alloy steel" are used not only to designate those ferrous metals, including irons and steels, having an alloy content effective to alter the electrochemical potential, but also include plain cast irons and carbon steels.

The present invention is a species of the generic invention disclosed and claimed in applicant's copending application, Serial No. 207,485, filed May 12, 1938, and which matured on April 8, 1941, as Patent No. 2,237,321.

Although the invention has been described in considerable detail with respect to pipe lines as a preferred embodiment, other structures, objects, etc., which are exposed to similar conditions are to be considered equivalents and to come within the scope of the invention as described in the specification and defined by the appended claims.

I claim:

1. As an article of manufacture, a composite soil pipe resistant to penetration by pit corrosion when in the soil composed of at least two and not more than three structural iron base metal layers, the exposed layer being less noble than the under layer by a potential difference of about 0.07 to 0.2 volt, said layers being in good electrical contact over substantially their entire contacting surfaces, said exposed layer being of substantially greater thickness than a mere coating and both layers contributing structurally and appreciably to the strength of the pipe.

2. As an article of manufacture, a composite soil pipe resistant to penetration by pit corrosion when in the soil and being constructed of two structural layers of steel, the under layer containing alloying material in sufficient amount to render it more noble than the outer layer by a

potential difference of about 0.07 to 0.2 volt, both layers contributing structurally and appreciably to the strength of the pipe.

3. As an article of manufacture, a composite soil pipe resistant to perforation by pit corrosion when in the soil and when containing a corrosive fluid, said pipe being made of three structural layers of steel, the intermediate layer containing alloying material in sufficient amount to render said intermediate layer more noble than the outside layers by a potential difference of about 0.07 to 0.2 volt and all layers contributing structurally and appreciably to the strength of the pipe.

4. As an article of manufacture, a composite soil pipe resistant to penetration by pit corrosion when in the soil having an outer structural layer of plain carbon steel exposed to the soil and an under structural layer of steel bonded thereto containing up to about 5% nickel to render the under layer more noble than the outer layer by a potential difference of about 0.07 to 0.2 volt, each layer being of substantial thickness and contributing structurally and appreciably to the strength of the pipe.

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