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APPARATUS FOR PREVENTING CORROSION IN OIL WELLS

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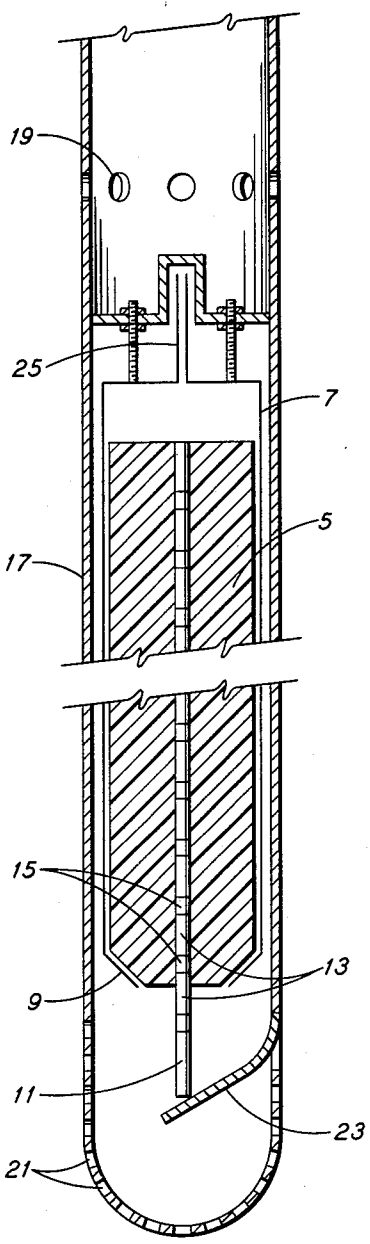


FIG. 1

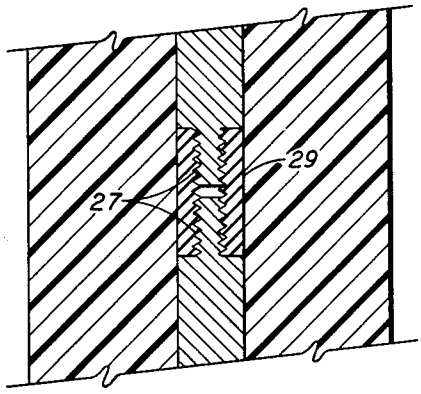


FIG. 2

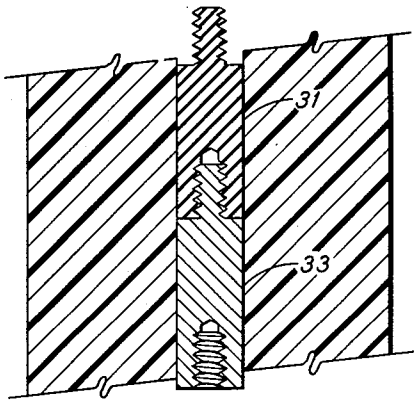


FIG. 3

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APPARATUS FOR PREVENTING CORROSION IN OIL WELLS

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4 Claims. (Cl. 166—243)

My invention relates to apparatus for injecting material at the bottom of a well, and particularly to apparatus for injecting corrosion inhibitors into an oil well.

Corrosion of ferrous metal surfaces in contact with the producing streams of oil wells has long been recognized as a serious operating problem by petroleum producers. Considerable research effort has been directed to this problem, and several methods of reducing corrosion rates and therefore reducing the frequency of replacement of well tubing, sucker rods and other subsurface apparatus, have been proposed.

Chemists have found a number of compounds which satisfactorily retard corrosion. Examples of these products are sodium arsenite, arsenous oxide, sodium dichromate and compounds of antimony. However, the development of completely satisfactory methods of introducing these compounds into a well to effectively control corrosion has long been a problem upon which much time and effort has been spent to seek a satisfactory solution.

According to prior art teachings of which I am aware, some of these corrosion inhibitor compounds are mixed with a weighting agent, such as metallic zinc, and are pelleted with a binding compound, such as alumina gel or starch. The pellets thus formed have a specific gravity appreciably greater than that of well fluids and are dropped into the well tubing at predetermined intervals of time to sink to the bottom of the hole and dissolve slowly, releasing corrosion prevention materials over a prolonged period of time. If properly applied, these pellets are capable of controlling corrosion over an extended period of time. However, production must be interrupted periodically for the application of these pellets and must not be resumed until they have fallen to a sufficient depth in the well so that the corrosion inhibitor will contact the entire length of tubing and thus give optimum corrosion protection.

The corrosion problem is of sufficient severity that such time-consuming corrosion inhibiting practices as described above are, nevertheless, followed in some wells. In other wells in which the corrosion problem is less aggravated, the expense of the use of pelleted corrosion inhibitors is too great economically to justify its use. In these cases, corrosion of the well equipment is accepted as the lesser of the two evils.

It is a further object of my invention to provide apparatus for injecting corrosion inhibitors into producing wells.

A further object of my invention is to provide a device which can be placed adjacent the bottom of a producing oil well to release automatically over a prolonged period of time predetermined amounts or concentrations of a corrosion inhibiting compound to effectively provide protection from corrosion to the metal apparatus and equipment situated in the well.

It is a further object of my invention to provide apparatus for injecting chemical compounds at the bottom of oil wells.

It is a still further object of my invention to provide a

metering system which will eject a chemical compound at a predetermined slow rate.

A number of corrosion inhibitors are commercially available which will adequately protect the metal parts of well equipment if applied at the rate of from 1 to 100 parts per million of well water. If an adequate amount of such inhibitor could be placed at the bottom of a producing well and released at a rate slow enough to give only the desired concentration of inhibitor, a sufficient charge of inhibitor could be placed in the well at relatively infrequent intervals, of the order of one year, to provide protection from corrosion for this period.

To achieve maximum usefulness in the field, the injection device should be one which is compatible with the present types of well equipment. It is desirable that the injector have a maximum diameter no larger than the tubing collars of the well. For convenience of use, it is desirable that it be no longer than 50 feet, and preferably no longer than 30 feet. Desirably, it may have mechanical characteristics such that it need not be serviced during the time in which it is dispensing a charge of corrosion inhibitor. For convenience of use, it is desirable that it be self-contained in the sense that it not be connected to the pumping rod or the electrical cables running through the annulus.

An injector 40 feet long and having an inner chamber of 2½ inches will have a capacity of approximately 4500 cubic inches. If the inhibitor is to be dispensed at the rate of 0.14 cc. per minute, it will remain available for a period of a year. Or stated differently, if the well known inhibitor compound, sodium chromate ($Na_2CrO_4 \cdot 2H_2O$), were dispensed continuously for a period of one year at the above rate, the inhibitor concentration continuously would be 25 p. p. m. in a well producing about 100 barrels of water daily. Wells can be treated successfully for corrosion control with injection of sodium dichromate at rates of about 25 p. p. m. active inhibitor.

For an injector for solid corrosion inhibitor to be acceptable to operating personnel of wells and to be practical from an economic viewpoint, it must be so arranged that it requires a minimum of attention over an extended period of time. By my invention I provide a metering system for use with solid corrosion inhibitors which is positive in operation, demands a minimum of attention, and is compatible with present well operating practices.

My invention comprises the use of solid blocks of inhibitor supported in limited contact with well fluids by a rod consisting of a number of sections of two metals arranged alternately along the rod. One of the metals is more noble than the other and the point of contact between successive sections forms a bimetallic junction. Bimetallic junctions on the rod are exposed to well fluid, and one of the metals is corroded away at the junctions. After corrosion has proceeded for a predetermined period of time, the rod breaks, lowering the block of inhibitor further into the well and exposing another volume of inhibitor to well fluids.

The novel features which comprise my invention are set forth with more particularity in the accompanying claims. The invention itself, with respect to the details thereof, together with its additional objects and advantages, may be better understood from the following description of a specific embodiment with reference to the accompanying drawings, in which:

Figure 1 shows a schematic drawing of an embodiment of apparatus according to my invention.

Figure 2 shows a detailed view of a coupling used in an embodiment of apparatus according to my invention; and

Figure 3 shows a modified coupling for an embodiment of apparatus according to my invention.

Figure 1 shows apparatus for injecting into a well stream

measured amounts of easily soluble corrosion inhibitor compounds. A solid stick of inhibitor 5 which may be 40 feet in length and 2½ inches in diameter is placed within an inner feeder tube 7. The lower end of the feeder tube is open except for a rubber slip sleeve 9 which covers a portion of the end of the stick of inhibitor 5. Cast within the inhibitor and protruding from its lower end is a rod 11 having alternate long sections 13 joined to intermediate shorter sections 15 of copper. A bimetallic joint is formed at the junction between one section 13 of magnesium and the section 15 of copper. While the two sections need not be composed of copper and magnesium, they must consist of one metal and a less noble metal. The inner feeder tube 7 and inhibitor stick 5 fit within an outer support tube 17, which is a cylindrical tube having perforations 21 at its lower end to admit fluid to the exposed portion of the inhibitor stick 5. It is attached to the lower portion of the well tubing below the section which has perforations 19 which admit fluid flow to the well pump or out of the well through the tubing string. A curved support plate 23 extends across a portion of the outer support tube near its lower end. The lower end of the rod 11 presses against the support plate 23 and supports the weight of the inhibitor stick 5. An annular area around the inner feeder tube 7 permits the flow of well fluid up the outside of the inner feeder tube to the vent 25. The outer support tube 17 is connected to the tubing string in a position below the well pump. The inhibitor stick 5 is loosely fitted to slip downward inside the inner feeder tube 7 and is prevented from doing so only because of the metal support rod 11 cast into the stick 5. A short section of this rod 11 projects below the bottom of the stick 5 and rests against the inclined support plate 23.

In the practice of my invention, the section 17 containing the corrosion inhibitor is affixed to the end of the tubing string and thus introduced to the bottom of the well. As the injector apparatus is lowered into the well, the space between the inner feeder tube 7 and outer support tube 17 contains air which is sealed off when the standing fluid level in the casing is reached. Further lowering of the device causes this captured air to be compressed and the fluid to rise in the annular space between the tubes. Well gas and the compressed air limit the amount of well fluid which enters the device.

The air space between the tubes 7 and 17 and above the inhibitor stick 5 may be filled with oil after assembly at the surface. Since oil has a lower compressibility than air, the fluid level in the inner tube 7 will be lower when oil is used as a filler. A wax seal may be poured over the lower end of the stick and for a distance into the space between the tubes 7 and 17. The wax will hold the oil in place while the device is lowered into the well. The wax will melt at bottom-hole temperatures, and the apparatus is ready for operation. For some applications of the present invention, oil may be preferred over air due to its lower compressibility. If, however, it is important that the apparatus be such as is easily loaded at the surface, air will be more desirable.

The vent riser 25 from the inner tube 7 is open to the support tube 17 at the highest elevation in the inhibitor chamber and permits the pressures to be equalized at the top and bottom portions of the stick 5. The position of the risers is such that, after the apparatus is in position in the well, the fluid level between the tubes will be below the top of the vent riser, and no water can enter the inner tube.

The inner tube 7 may be recharged after the tubing string, including the tubes 7 and 17, have been removed from the well. The detachable lower section of the support tube 17, including the inclined support plate 23, is removed to permit the extraction of the empty inner tube 7. A new inner tube containing a full charge of inhibitor is placed in the outer tube 17. The detachable lower section of the support tube 17 is replaced, and the inhibitor injector is replaced in the well as a portion of the tubing string. As the apparatus is lowered into position at the bottom of the well, it entraps gas which is compressed under the increasing hydrostatic pressure toward the bottom of the well. After the apapratus is in position at the bottom of the well, gas from well fluids will gradually displace any liquid between the inner and outer tubes 7 and 17, and the entire inhibitor stick will be left in a gas pocket. A bimetallic coupling between a magnesium section 13 and a copper section 15, however, is exposed to well fluids at all times.

Operation of the apparatus is as follows: the apparatus is lowered into the well, and a gas pocket forms in the outer support tube 17 to a point extending below the lower terminus of tube 7. The exposed end of the inhibitor stick 5 cannot dissolve appreciably upward into this gas gap. The bimetallic coupling between the copper 15 and the magnesium 13 is exposed to well fluids, however, and solution of the less noble metal progresses at a steady rate. This is called bimetallic corrosion. The anodic metal corrodes at the point of contact. The magnesium rod 13 at the area of contact with the copper section 15 corrodes and weakens the rod 11. When the couple is almost broken by dissolution of the magnesium, the weight of the inhibitor stick 5 forces the rod 11 to bend at the corroded coupling, and the stick is lowered until the portion of the rod above the coupling touches the support plate 23. The small bottom piece of rod which has been weakened and bent out of contact with the plate 23 soon corrodes completely through at the coupling and falls into the lower portion of the outer support tube 17 where corrosion of the magnesium will continue. Part of the inhibitor stick 5 is now exposed to well fluid and gradually dissolves back to the edge of the gas pocket, thus exposing another bimetallic coupling 15. The second bimetallic coupling begins to corrode until it, too, gives way, lowering the inhibitor stick 5 further into the well. This process is repeated until the entire block 5 of inhibitor is consumed.

The present invention, then, provides apparatus by which the well is periodically given a measured slug of inhibitor. The inhibitor may be such as will dissolve either rapidly or slowly in the well fluids. In the preferred embodiment of my invention, however, the inhibitor used would be one which would dissolve completely in a period much shorter than the time required for the destruction of a bi-metallic coupling in the support rod 11. Using such an inhibitor, the well fluids would be receiving a new charge of inhibitor at periodic intervals, and the quantity of inhibitor injected would be so selected that its corrosion inhibiting effect would continue until the time at which another bi-metallic coupling on the support rod 11 gives way and another charge of inhibitor is injected. When the inhibitor stick 5 slips downward, an amount of liquid equal to the volume of the exposed stick will enter the space between the inner tube 7 and outer tube 17 but will not enter the inner tube. This liquid will be displaced gradually by well gas so that there will be another gas gap formed each time the inhibitor stick moves downward. The rubber slip sleeve 9 is in intimate contact with the inhibitor stick when the stick 5 slips downward, and tends to prevent liquid from entering the narrow annular space between the stick 5 and the inner tube 7. The sleeve 9 also deflects gas bubbles into the space between inner and outer tubes 7 and 17, thereby aiding the displacement of any liquid in this space.

The inhibitor stick 5 and support rod 11 are so selected that both the time between stick exposures and the amount of stick exposure can be selected. The time required for coupling failure is controlled simply by selecting the difference between electrode potentials of the two metals chosen. The above-described magnesium-copper couple corrodes rapidly; whereas one could use an iron-copper support rod which will corrode more slowly. The amount of inhibitor exposed at each stick slippage is

determined by the distance between couplings and the distance between the gas gap and the support plate.

One satisfactory arrangement of this apparatus involves the use of a support rod which has a length of 6 inches between bimetallic couplings. Where the couplings are designed to fail after 5 days' exposure, a well can be treated by periodic injection for 400 days by the use of an inhibitor stick 40 feet in length.

It is apparent that a magnesium support rod will be subject to accelerated corrosion where it is in contact with the ferrous support plate. This contact causes the magnesium to dissolve very near the contact point, causing a slight lowering of inhibitor stick **5**. This may be prevented by the use of an insulating pad on the support plate **23**. It is believed, however, that it is satisfactory to permit the magnesium rod to be in contact with the metal support plate **23** since the corrosion at that point of contact will be slight and the rate of exposure of the inhibitor stick will continue to be controlled by the rate of corrosion of the bimetallic junction.

The apparatus shown in Figure 1 will operate satisfactorily if the sections **13** and **15** are both made of magnesium or if the rod **11** is a single stick of magnesium and if the support plate **23** is made of copper. The rod **11** will corrode at the point of contact with the plate **23** and lower the block **5** of inhibitor into the well fluid. This provides introduction of the inhibitor at a constant rate. The rate of corrosion of the magnesium and its associated rate of inhibitor dissolution can be changed by selection of a metal support plate other than copper.

The detailed construction of the bimetallic junction is shown in Figure 2. A threaded portion **27** on each of the two sections of magnesium rod is held by a threaded collar **29** constructed of copper. The areas of contact between the copper and the magnesium which are exposed to well effluent will be subject to accelerated corrosion.

An alternative arrangement is shown in Figure 3, in which a threaded hole is prepared in the copper member **31**. A threaded bolt-like protuberance on the magnesium member **23** screws into the hole in the copper member **31**.

Although I have shown and described a preferred embodiment of my invention, it will be apparent that many modifications thereof are possible without departure from the spirit and scope of the invention. For example, my invention may be used to introduce materials other than corrosion inhibitor into an oil well. I do not intend, therefore, to limit my invention to the specific embodiment disclosed.

I claim:

1. For use in dissolving a soluble solid into a well, the combination comprising a container having a closed upper end and an open lower end, a support affixed to said container, a metal member resting on said support, a plurality of bimetallic joints on said member, a block of said solid slidably disposed within said container and rigidly affixed to said member, one bimetallic joint being exposed to well fluids.

2. In combination, a container having an open and a closed end, a block of solid material within said container, a rod having a plurality of bimetallic joints, said rod having all but one of its bimetallic joints embedded within said block of solid, said rod having an exposed end section extending through the open end of said container, means affixed to said container for supporting said rod at its exposed end, said open end of said container being positioned vertically downwardly of said closed end.

3. Apparatus according to claim 2 in which the portion of said block within said container is substantially completely immersed in oil.

4. Apparatus for feeding a soluble solid corrosion inhibitor into well fluids in which it is soluble comprising a container immersed in said well fluids and having a closed end and an open end, a quantity of said soluble solid corrosion inhibitor slidably contained within said container and exposed to said well fluids at said open end thereof, a metallic rod having bimetallic transverse joints located at spaced-apart intervals longitudinally of said rod, said joints being subject to bimetallic corrosion in said well fluids, said rod having one longitudinal portion thereof enclosed within said quantity of corrosion inhibitor and another longitudinal portion thereof extending from said quantity of corrosion inhibitor and outwardly through the open end of said container into contact with said well fluids, means to bias said quantity of corrosion inhibitor and said rod outwardly of said container through the open end thereof, and a stop engaging the said portion of said rod which extends from said quantity of corrosion inhibitor.

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