United States Patent [19]

Smith et al.

[11] **3,891,394**

[45] **June 24, 1975**

[54] **CRYSTAL GENERATOR TO INHIBIT SCALE FORMATION AND CORROSION IN FLUID HANDLING SYSTEMS**

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[73] Assignee: **Love Oil Company, Inc.**, Scottsdale, Ariz.

[22] Filed: **Apr. 10, 1974**

[21] Appl. No.: **459,548**

[52] **U.S. Cl.** .... **23/273 R;** 23/301 R; 21/2.7 R; 21/61; 75/156.5; 75/159; 166/244 C; 166/242; 159/DIG. 13; 203/7; 252/387; 252/175; 204/196; 204/197

[51] **Int. Cl.** **B01d 9/02;** C23f 13/00

[58] **Field of Search** .... 159/DIG. 13; 203/7; 166/244 C, 242, 57, 312; 252/387, 175, 80; 75/156.5, 159; 204/196, 197; 21/2.7 R, 61; 23/252 A

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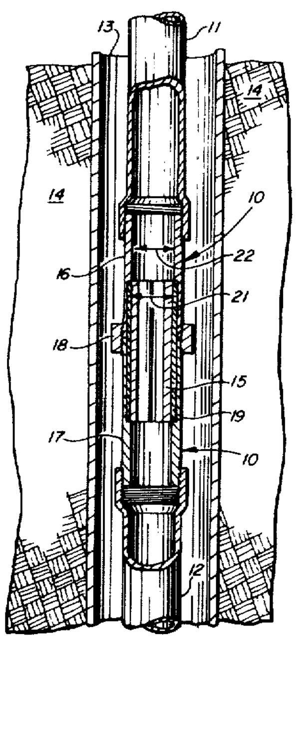
[57] **ABSTRACT**

An improved crystal generator comprising a specially formed pressure differential device in the fluid flow line of a well or other fluid flow system employing a special core which generates particular crystal formation(s) in the pumped fluid. The crystal generator stimulates the formation of "seed" crystals in the pumped fluid, which, as a result of turbulent conditions of the fluid in the flow line, are held in suspension, where they act as sites of deposit for older crystals of scale, thereby removing old formations of scale on well walls and associated equipment surfaces and discouraging formation of new scale deposits.

10 Claims, 4 Drawing Figures



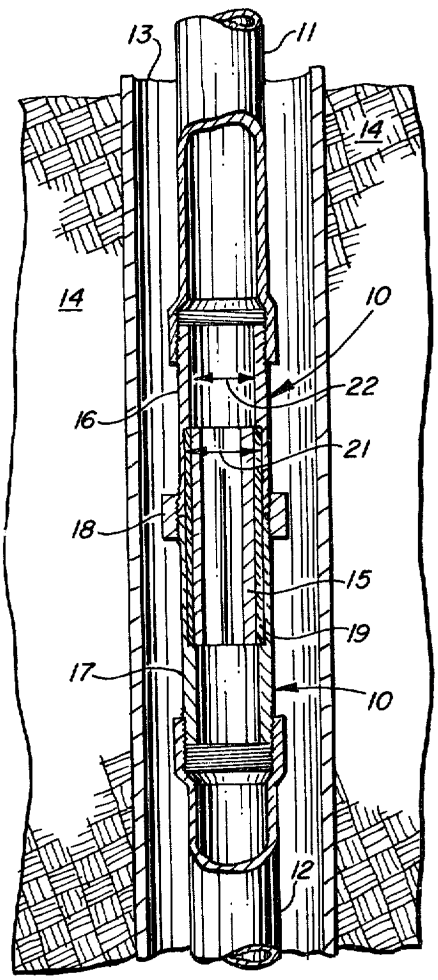


FIG. 1

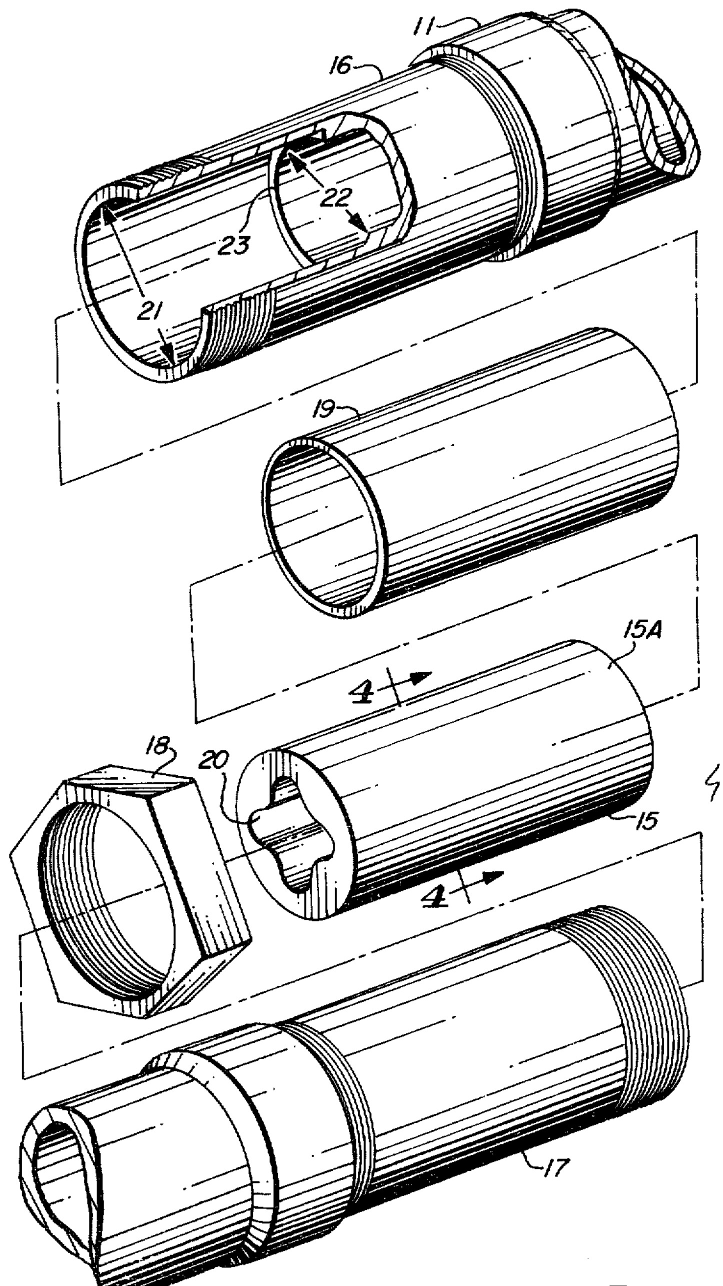


FIG. 2

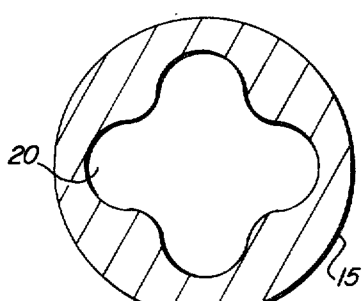


FIG. 4

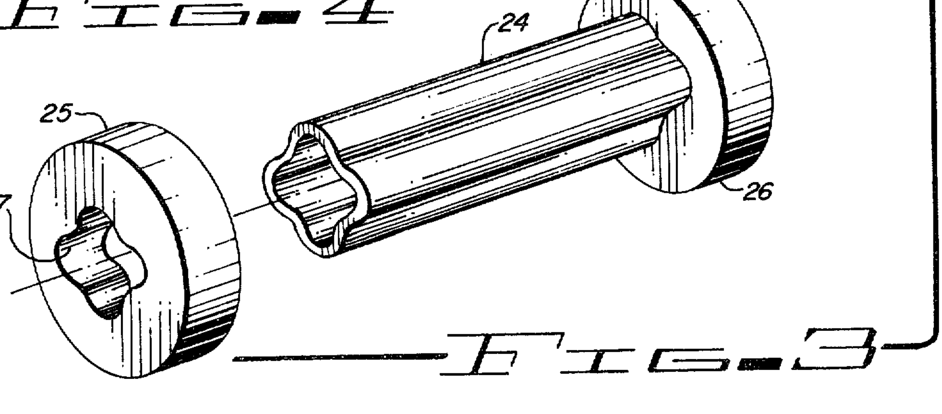


FIG. 3

CRYSTAL GENERATOR TO INHIBIT SCALE FORMATION AND CORROSION IN FLUID HANDLING SYSTEMS

BACKGROUND OF THE INVENTION

In water and other fluid handling systems including wells, boilers, tanks and delivery lines, the costly problems of corrosion, scale and electrolysis are nearly always encountered.

These problems arise largely because of the presence of minerals and dissolved gases present in the fluids, especially those obtained from natural sources. This is true, for example, in the case of both potable and non-potable water. For potable water the Federal Government recommends a maximum mineral content of 500 parts per million (ppm) dissolved solids, including 250 ppm of sulfates, 250 ppm of chlorides, 1 ppm of fluorides and 0.3 ppm of iron. Non-potable, brackish and/or conate water in the oil fields typically contains more than 30,000 ppm dissolved solids, including 55 ppm sulfate, 15,000 ppm chloride and 3 ppm iron.

Such minerals form scale compounds through chemical reactions, and as they collect on the walls of pipes and other equipment they inhibit heat transfer or produce corrosion through metallic grain boundary attack, the tendency for either ill effect being dependent upon prevailing temperature and pressure conditions. For example, at atmospheric pressure, a particular sample of water will show scale forming tendencies at high temperatures (125° to 205° Fahrenheit) and the same sample of water will show corrosive tendencies at low temperatures (35° to 80° Fahrenheit).

These problems are complicated by the presence of electrolytic action, the minerals acting as an electrolyte and forming in cooperation with adjacent dissimilar metals an electrolytic cell. Electrical currents flowing from the electropositive metal involved in such combinations produces oxidation of the anode material which rapidly consumes the pipes or other metal parts.

Extremely heavy financial losses result from the accumulations of scale and from the corrosive actions described. Losses of this nature are experienced in such industries as paper-making, chemical manufacturing, metal processing, cement and lime operations, rubber-making, food processing, etc. The petroleum industry sustains heavy losses due to the formation of scale and paraffin in oil well pipes, pumps, flow lines, tanks and other equipment, and the problem is especially serious and costly in the case of the pumping operations where the well must be shut down periodically to clean out paraffin deposits and repair or replace corroded rods, fittings and tubing.

Various methods and devices have been employed in the past to combat these problems. Special coatings or paints have been applied to the interior surfaces of containers and pipes. Electro-positive metals such as zinc or magnesium have been installed inside pumps and lines, these metals acting as sacrificial elements, replacing the working parts as the anode material and thereby preventing corrosion of the working parts by electrolytic action. Special insulating spacers are employed to prevent contact between dissimilar metals. Deliberate introduction of electrolytic action inside such equipment has also been employed to inhibit scale formation.

In U.S. Pat. No. 3,448,034, by L. F. Craft, et al., the inventors propose the use of a stabilizing element in the

form of a metal core inserted inside the tubing of a well. The core material of the stabilizing element comprises a mixture of several metals in a crystalline structure having non-conductive and non-sacrificing characteristics, its introduction into the fluid flow path producing a stabilizing effect which prevents precipitation of solids and subsequent collection as scale on equipment surfaces. While the chemistry involved in this stabilizing means was stated as not being fully understood by the inventors, they claimed reduction of corrosion and scale formation.

Although the methods and apparatus employed in the prior art reduce scaling, there is still considerable room for improvement in predicting scale removal and corrosion control since scaling is still being formed in fluid flow pipes and associated equipment. A very significant potention for additional savings and reduced costs for industry and the consumer in these vitally important operations and processes still remains.

SUMMARY OF THE INVENTION

In accordance with the invention claimed, an improved method and apparatus is provided for the reduction of scale formation and corrosion in fluid handling equipment and particularly in the tubing and hardware employed in pumping equipment.

It is, therefore, one object of this invention to provide an improved method and apparatus for the reduction of scale formation and corrosion in fluid handling equipment.

Another object of this invention is to provide such apparatus in a form specifically adapted for application to pumping equipment and most particularly for use in oil pumping and oil flow operations.

A further object of this invention is to provide such a specifically adapted apparatus in the form of a specially shaped hollow core through which the pumped fluid flows, an appreciable part of the mineral content of the fluid being thereby caused to enter a crystalline form while remaining suspended in the fluid to be carried through the pump and associated lines without attaching itself to the walls of the equipment or producing corrosive effects.

A still further object of this invention is to produce such a crystallizing effect in the specially shaped hollow core through the use of appropriately proportioned alloys in the core materials, the alloy contents being chosen to stimulate or generate in the crystalline structure of the alloys the crystalline structures of the mineral crystals to be precipitated.

A still further object of this invention is to provide such a specially shaped core in a geometric form which provides for a relatively large inner surface area for maximum contact with the fluid while at the same time providing a relatively small cross-sectional core area or fluid flow area to produce within the core a high fluid velocity and a significant drop in head pressure. These conditions of area, flow rate and drop in head pressure have been found to be most effective in inducing crystallization of minerals in a manner which inhibits their collection on equipment walls.

Further objects and advantages of the invention will become apparent as the following description proceeds and the features of novelty which characterize this invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

BRIEF DESCRIPTION OF THE DRAWING

The present invention may be more readily described by reference to the accompanying drawing, in which:

FIG. 1 is a partial perspective broken-away view showing interior and exterior details of the apparatus of the invention installed in an oil pump casing;

FIG. 2 is an exploded view of the several parts comprising the apparatus claimed;

FIG. 3 is a perspective view of an alternate construction for a key element of the apparatus shown in FIG. 1; and

FIG. 4 shows the cross-sectional configuration of the central core of the apparatus taken along line 4—4 of FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring more particularly to the drawing by characters of reference, FIG. 1 illustrates a crystal generator **10** installed, for example, between two sections, **11** and **12**, of pump tubing contained in a well casing **13** which is surrounded by an earth or rock bed **14**. It should be recognized that the generator may be hung directly below a pump in a pumping well or beneath a packer or hanger in a flowing well.

The crystal generator **10** comprises a specially shaped hollow core **15** having a cylindrical or other geometrically shaped outer surface, two hollow cylindrical support members **16** and **17**, each of which supports by containment one-half the length of the core **15** and each of which has external pipe threads at both ends, a retaining nut or coupling **18** into which adjoining ends of support members **16** and **17** are threaded and thereby secured, and an insulating bushing **19** or inert coating which snugly surrounds the outer surface of core **15**.

Support members **16** and **17** are of substantially identical configuration, each having a length which is approximately equal to the length of core **15**. Each member is divided lengthwise into two sections having different inside bore diameters. The bore of member **16** has, for example, a first diameter **21** along the lower half of its length and a second diameter **22** along the upper half of its length. Diameter **21** is slightly greater than the outside diameter of an inert coating or bushing **19**, hereinafter referred to as a bushing for purposes of discussion so that bushing **19** covering core **15** fits snugly but without interference inside the bore of member **16** having diameter **21**. The second bore diameter **22**, however, is somewhat smaller than the outside diameter of bushing **19** so that the upper extremities or ends of core **15** and bushing **19** fit against the end of the inner surface of member **16** formed by the junction of the two sections of member **16** characterized by different bore diameters. Similarly, the lower half of core **15** is contained within the upper half of member **17**. As noted from FIG. **1**, the upper half of member **17** has the larger bore diameter and the periphery of the lower ends of core **15** and bushing **19** resting against the upper end of the inner surface of member **17**. In the preferred manner of construction, bushing **19** is slightly longer than core **15** and is bonded or sprayed to the surface of core **15** so that only the ends of the bushing **19** rather than the ends of core **15** make physical contact with members **16** and **17**.

FIG. 2 illustrates with greater clarity the geometric forms of the individual parts of crystal generator **10**. Member **18** as shown is threaded at one end into tubing **11**. The junction of the two sections of member **16**, characterized by the two different bore diameters **21** and **22**, forms a step or flange **23** which bears against the hollow cylindrical bushing **19** covering the upper end of core **15** when generator **10** is assembled as shown in FIG. **1**.

Core **15** comprising a cylindrical outer surface **15A** has a cylindrical inner bore **20** extending through its full length and shown in FIG. 2 for purposes of illustration as having a four-leaf clover cross-sectional configuration. The contour was chosen to provide maximum surface area simultaneous with minimum cross-sectional flow area in a pattern which is easy to form by convenient and inexpensive manufacturing techniques such as casting, extruding or by relatively simple machining operations.

An alternate construction for core **15** is illustrated in FIG. 3 where a center section **24** having the form of a ribbed down-spout pipe affords the same cloverleaf inner bore configuration as does core **15** of FIGS. **1** and **2**, while two short cylindrical caps **25** and **26** also having a cloverleaf inner bore **27** are attached to the ends of center section **24** in a butt arrangement or slidably mounted on the end of an axle. End sections **25** and **26** can be conveniently fabricated from an appropriate insulating material so that the insulating function alternatively supplied by bushing **19** in FIGS. **1** and **2** is here accomplished by sections **25** and **26**.

Crystal generator pipe **10** is mounted in the well by threading nut **18** part way onto the lower end of member **16** having bore diameter **21**. At this time nut **18** is turned onto member **16** only a short way so that approximately half the threads of nut **18** are engaged by the threaded end of member **16**. Core **15** is then inserted into the lower end of member **16**. The upper end of member **17** is then slipped over the exposed lower end of core **15** and member **17** is then turned into the lower end of nut **18**. With proper dimensioning the upper and lower ends of core **15** will bear against the flanges in the inner surfaces of members **16** and **17** as member **17** is turned into nut **18** to a point just short of the meeting of the upper end of member **17** with the lower end of member **16**. The crystal generator **10** is at this point assembled into a rigid unit, the core **15** having been confined within members **16** and **17**, and the members **16** and **17** having been securely bound together at their adjoining ends by nut **18**.

The generator **10** is then installed into well tubing **11** and **12** by turning the threaded lower end of member **17** into the internally threaded upper end of tubing **12** and by threading the internally threaded lower end of tubing **11** over the threaded upper end of member **16**.

The assembled crystal generator as illustrated in FIG. **1** now provides a path through it for the flow of fluid which in the operation of the well flows upward from tubing **12**, through the cloverleaf bore **20** of core **15** and tubing **11**.

To understand the principles of crystallization of minerals carried by fluids, reference is made to Murphy and Rousseau's *Foundations of College Chemistry*, Ronald Press Company, New York, copyright 1969, pages 252–253, wherein it is stated that:

"When one cools a saturated solution of a solute whose solubility increases with temperature, excess solute should come out of solution at such a rate that the solution remains saturated at all times as the temperature decreases. In many instances, however, if the solution is left undisturbed, the excess solute over that required for saturation does not separate at the lower temperature but remains in the dissolved state. The solution then contains a higher concentration of solute than it would if it were in equilibrium with undissolved solute at the same temperature, and it is described as being supersaturated. A supersaturated solution is in a metastable state, that is, it may remain unchanged for a long time if it is not disturbed, but once the excess solute begins to separate, the process continues until equilibrium is reached.

"A supersaturated solution cannot exist for long in the presence of undissolved solute, so that crystallization from such a solution can usually be started by adding a crystal of the solute as a 'seed.' The phenomenon of supersaturation is reminiscent of the supercooling of a liquid and arises from similar causes. As would be expected, complex substances are often most prone to form supersaturated solutions because the probability of the individual particles colliding in just the right orientation to begin to build the crystal lattice is small unless an appropriate matrix is present. Again, as with a supercooled liquid, an air bubble, a piece of dirt, a chip of glass, or a crystal of some other substance of similar structure may serve to induce crystallization."

The operation of the crystal generator **10** employs the above principles.

Core **15** is fabricated from a special formula of a number of metals by means of a process which encourages the formation of a large number of alloys. The specific alloys incorporated in the core material are chosen in a deliberate attempt to simulate the crystal shapes of the important minerals contained in the fluids to be handled by the pump in which the crystal generator **10** is to be installed. Metals incorporated in the alloys of one configuration of core **15**, for example, include the following in the approximate proportions indicated:

copper, from 54 percent through 69 percent
zinc, from 1 percent through 23 percent
nickel, from 9 percent through 27 percent
lead, from 0.9 percent through 11 percent
tin, from 1 percent through 7 percent

The selection of each metal listed is directed toward the provision of a particular crystal geometry as called for by the mineral composition of the particular fluid being handled. Where there is a high concentration of calcium carbonate, for example, the nickel content is especially appropriate because of the similarity between the extremely small "seed" crystals of calcium carbonate and those of nickel heat treated to the Beta phase.

As the fluid flows into the crystal generator **10** from tubing **12** entering core **15** with its specially shaped bore **20**, there is a sudden pressure drop accompanied by a sudden increase in flow velocity because of the smaller cross-sectional area of bore **20** relative to the cross-sectional area of tubing **12**. Because of the abrupt discontinuity at the entrance to core **15** there is also present inside core **15** a high degree of turbulence. The increased velocity and the turbulence produces a vigorous washing of the inner surfaces of the core **15**, and this vigorous washing in combination with the maximized surface area provided inside core **15** owing to the special cloverleaf bore **20** provided in the design insures a high degree of contact between the pumped fluid and the deliberately formed alloy crystal structures.

A number of conditions incorporated into the design of crystal generator **10** cooperate to produce crystallization of the dissolved minerals inside core **15**. For instance, contact of the dissolved mineral molecules with the alloy crystals encourages the initial formation of the mineral crystal with the alloy crystal having the effect of a "seed" crystal. The abrupt disturbance afforded by the sudden drop in pressure with the accompanying increase in velocity and the turbulence of the fluid within core **15** also aids in the initial crystal formation.

A second, more important function as taught herein is provided, however, by the high velocity and turbulence of the fluid. As the initial crystals are formed on the alloy surfaces they are immediately washed away by the violent action of the fluid before additional crystals may grow around the initial crystal and before such a growing crystal structure can attach itself permanently to the alloy surface. Furthermore, as the initial crystal is torn away from the alloy surface, the turbulence of the fluid produces a high degree of exposure of the crystal with additional mineral molecules of the same type so that the freed and suspended initial crystal rapidly grows as it passes on through core **15** and upward into tubing **11**. The high velocity and the turbulence have thus served to promote crystal growth around seed crystals suspended within the pumped fluid rather than on the surface of the core **15** where they would otherwise soon build up to choke off fluid flow through generator **10** and require a dismantling and cleaning operation.

The crystals thus formed leave crystal generator **10** in the form of a suspended "snow" which flows upward or through tubing **11**, and this crystal "snow" continues to serve as a constant supply of "seed" crystals around which further crystallization can occur as the fluid flows upward to surface equipment. The presence of such "seed" crystals in suspension encourages the rapid stabilization of the mineral solution to a state of equilibrium where the crystallization process ceases. Because such stabilization has occurred through crystallization around suspended "seeds" rather than on equipment surfaces, the crystallized minerals are carried on through the equipment to be discharged without detriment to tubing or equipment whereas they would otherwise have formed on tubing and equipment surfaces as scale which clogs the equipment and promotes corrosion.

The function of the insulating bushing **19** which surrounds core **15** is to insulate core **15** from members **16** and **17** and thereby to prevent electrolytic action between the dissimilar metals from which core **15** and members **16** and **17** are fabricated. Such electrolytic action would otherwise rapidly destroy or upset the seeding action of crystal generator **10** through corrosion or eddy currents as described earlier.

The crystal generator **10** is a very simple assembly employing parts which are readily adaptable for application in a broad variety of equipment. Its effectiveness in preventing scale and corrosion in oil well lines is currently of the highest significance, but its potential usage in other fluid pumping and processing operations is also of great importance.

It should be recognized that the disclosed crystal generator may work in fluid passageways of given fluids for agricultural, medical, oil, automatic or semi-automatic water conditioning, and the various home uses, even through made of wood or plastic, since the pressure drops and turbulence may be enough to start the crystal seeding action.

Although only two embodiments of the present invention have been illustrated and described, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims.

What is claimed is:

1. An apparatus for generating crystals in a fluid flow line to inhibit scale formation and corrosive action comprising: a fluid flow pipe,

a hollow core snugly fitting into said fluid flow pipe in a well having a bore configuration, the internal cross-sectional area of which is less than the cross-sectional area of the fluid flow pipe, said core being formed of an alloy comprising substantially 54 to 69 percent of copper, 1 to 23 percent of zinc, 9 to 27 percent of nickel, 0.9 to 11 percent of lead, and 1 to 7 percent of tin,

an insulating sleeve mounted around said core to prevent electrolytic action between said core and said fluid flow pipe,

the upstream end of said core, being mounted in said fluid flow pipe, providing a flange extending inwardly of the surface of the fluid flow pipe in which it is mounted to provide a means for creating a high velocity and turbulence of the fluid as it enters the bore of said core,

said high velocity and turbulence creating an abrupt disturbance which aids in crystal formation in the fluid which are washed away by the violent action of the fluid before additional crystals can grow around the initial crystals and form scale on adjacent equipment surfaces.

2. The apparatus for generating crystals in a fluid flow line set forth in claim 1 wherein:

the shape of the outside periphery of said core is cylindrical, and

said cross-sectional area of said bore is non-cylindrical in shape.

3. The apparatus for generating crystals in a fluid flow line set forth in claim 1 wherein:

the shape of said cross-sectional area of said core is in a cloverleaf configuration.

4. The apparatus for generating crystals in a fluid flow line set forth in claim 1 wherein:

said core is formed of an alloy designed to encourage the initial formation of mineral crystals with the alloy crystals.

5. The apparatus for generating crystals in a fluid flow line set forth in claim 1 wherein:

the shape of the outside periphery of said core is non-cylindrical, and

said cross-sectional area of said bore is non-cylindrical in shape.

6. The apparatus for generating crystals in a fluid flow line set forth in claim 1 in further combination with:

an insulating coating applied around said core to prevent electrolytic action between said core and adjacent dissimilar metal.

7. An apparatus for generating crystals in a fluid flow line to inhibit scale formation and corrosive action comprising:

a hollow cylindrical sleeve formed by two detachably connected, axially aligned sections,

said sleeve being provided with threaded ends for threadedly engaging with interrupted sections of a fluid flow pipe to form an interconnecting pipe section,

a hollow core for snugly fitting into said sleeve having a bore configuration, the internal cross-sectional area of which is less than the cross-sectional area of said sleeve, said core being formed of an alloy comprising substantially 54 to 69 percent of copper, 1 to 23 percent of zinc, 9 to 27 percent of nickel, 0.9 to 11 percent of lead, and 1 to 7 percent of tin,

the upstream end of said core when mounted in said sleeve and said sleeve in a fluid flow pipe providing a flange extending inwardly of the inner surface of the fluid flow pipe in which it is mounted to provide a means for creating a high velocity and turbulence of the fluid as it enters the bore of said core,

said high velocity and turbulence creating an abrupt disturbance which aids in crystal formation in the fluid which are washed away by the violent action of the fluid before additional crystals can grow around the initial crystals and form scale on the adjacent fluid flow pipe surfaces, and

an insulating sleeve mounted around said core to prevent electrolytic action between said core and said sleeve.

8. The apparatus for generating crystals in a fluid flow line set forth in claim 7 wherein:

the shape of the outside periphery of said core is cylindrical and said cross-sectional area of said bore is non-cylindrical in shape.

9. The apparatus for generating crystals in a fluid flow line set forth in claim 7 wherein:

said core is formed of an alloy designed to encourage the initial formation of mineral crystals with the alloy crystals.

10. The apparatus for generating crystals in a fluid flow line set forth in claim 7 wherein:

the shape of the outside periphery of said core is non-cylindrical and said cross-sectional area of said bore is non-cylindrical in shape.

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