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(54) **METHOD AND APPARATUS FOR TREATING FLUID WITH RADIO FREQUENCY SIGNALS**

VERFAHREN UND VORRICHTUNG ZUR BEHANDLUNG EINER FLÜSSIGKEIT DURCH RADIOFREQUENZSIGNALE

PROCEDE ET APPAREILLAGE DESTINES AU TRAITEMENT DE FLUIDES A L'AIDE DE SIGNAUX DE FREQUENCES RADIOELECTRIQUES

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Description

[0001] This invention generally relates to apparatus for, and a method of, treating a fluid. More particularly, the invention relates to the treatment of water, to condition it so that the build up of deposits of scale in a water-carrying conduit is resisted. Still more particularly, the invention relates to the generation of an electromagnetic field having generally circular flux lines for treating a fluid for the purpose aforesaid and for other purposes which will be referred to hereafter.

[0002] Impurities, such as calcium and magnesium ions, in water, form scale which, over time, adheres to the interior walls of water pipes. If the water is heated the formation of scale is accelerated and, hence, water heaters and steam boilers are particularly susceptible to scale buildup and to reduced heat transmission, higher fuel usage and even local overheating. In domestic plumbing systems, calcium and magnesium ions react with soap to resist the formation of suds, thereby preventing effective cleaning.

[0003] Many water treatment descaling systems have heretofore been proposed to condition water to resist such scale formation and buildup. For example, chemical solutions require constant replenishment and also adulterate the water. Another approach is to position erodible electrodes into the water. However, as the electrodes erode, they lose their effectiveness and, ultimately, also need replacement.

[0004] Still another approach positions magnets in direct contact with the water, However, such magnets can only collect magnetic debris and, eventually, the build-up of debris can occlude the pipe.

[0005] Yet another approach uses magnetic or electromagnetic fields, both exteriorly and interiorly of a piping system. However, such fields are local in action and, in any event, rely on the flow of water to transport the descaling effect to downstream areas of the water pipes.

[0006] It has been proposed, in WO,A,9200916, that fluid in a conduit can be treated by the application thereto by a succession of radio frequency signals. The signals are applied by establishing electrical contact with the conduit at two positions spaced from one another along the conduit. To this end, the described device has a pair of spaced apart terminals which engage the conduit when the device is secured thereto.

[0007] It is broadly the object of the present invention to provide for the application of the signal to the fluid in the conduit in a more convenient and efficient manner

[0008] According to the present invention, I provide an apparatus for treating a fluid contained in a conduit extending along an axis, comprising means for generating radio frequency signals, and means for applying said signals to the fluid in the conduit, characterised in that said means for applying the signals comprises:

a primary coil mounted to the exterior of the conduit;
means for energising the primary coil to generate a succession of radio frequency signals; and
a core of magnetically permeable material extending around the conduit and through the primary coil, for generating in the fluid to be treated an electromagnetic field having generally circular magnetic flux lines in generally co-axial relation with the axis of the conduit, and for propagating the field along the axis to treat the fluid upstream and downstream of the primary coil.

[0009] In accordance with one application of this invention, wherein the fluid is water, and it is desired to treat the water to resist scale deposits, the propagation of the electromagnetic field with the generally circular magnetic flux lines provides a very thorough descaling action. No chemicals, electrodes, magnets or other descaling device is mounted within the conduit. The descaling action is not local in effect but, instead, is propagated throughout the conduit even when the fluid is not flowing.

[0010] Preferably the core is of a ferrite material of high permeability magnetic properties. The primary winding may be a multi-wire ribbon cable having a pin connector and a socket connector at opposite ends of the cable. The pin connector has a row of pins, and the socket has a row of sockets. The connectors are interconnected to form a loop with the rows offset by one pin.

[0011] In another embodiment, the primary coil includes a dual-in-line package having a row of pins, and a printed circuit board having a row of sockets. The package is mounted on the board with the rows offset by one pin. A ferrite core extends through the primary coil and extends, e.g. coiled co-axially, around the conduit.

[0012] The energising means may include means, e.g. a microphone, for detecting the sound of fluid flowing along the conduit, and for generating an analog audio signal having a frequency proportional to the detected sound. The microphone, in effect, detects the turbulence in the water which causes the sound to be generated.

[0013] The energising means preferably further includes a filter for removing noise from the audio signal, a transducer for converting the audio signal into a Series of digital pulses whose frequency is proportional to the frequency of the audio signal, a converter for converting the digital pulses to a DC voltage whose amplitude is proportional to the frequency of the audio signal and another transducer for changing the DC voltage to a train of drive pulses applied to the primary coil. In turn, the primary coil causes the succession of radio frequency signals to be generated.

[0014] Each radio frequency signal may have a frequency in a range from 50 to 500 KHz. Each radio frequency signal may have a sinusoidally variable amplitude which diminishes from a maximum value to zero. Preferably, the signals have random wait intervals between signals.

[0015] In an arrangement as above set forth, the electromagnetic field is automatically produced and is direcdy proportional to the condition of the piping system, and especially to the amount of scale therein. The arrangement is preferably never turned off, thereby ensuring a minimum treatment level. The treatment is maintained whether the water flows or not, which is of particular benefit in domestic installations where water flow is intermittent.

[0016] As above referred to, the invention is also useful for treating a fluid for purposes other than or in addition to resisting build up of scale deposits in a water-carrying conduit. The invention is potentially useful in its effect on biological conditions in a fluid, e.g may affect the growth of algae or bacteria in water. Further, the invention has been found to have an effect on a flocculation process; in a system treated in accordance with the invention the floc settled more quickly than when untreated.

[0017] The invention has been found to have an effect on crystal growth generally, in fields other than the deposition of scale. When crystals are grown from a solution treated in accordance with the invention, crystal size and the extent of hydration of the crystals are affected. Further, some chemical reactions involving ions and free radicals as intermediates are affected by treatment in accordance with the invention.

[0018] The invention has been found to be particularly advantageous in inhibiting corrosion of ferrous metal pipes containing water.

[0019] The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. the invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings.

Figure 1 is an electronic circuit diagram of an arrangement which is not in accordance with the present invention but which may, modified as detailed hereafter, be used in the invention;
Figure 2 is a front elevational view of the arrangement of Figure 1 mounted on a conduit;
Figure 3 is a bottom end view of Figure 2;
Figure 4A is a perspective view of magnetic flux lines generated in accordance with the arrangement of figure 1 and surrounding the conduit;
Figure 4B is a cross-sectional view of Figure 4A away from the contact zones;
Figure 5 is a broken-away elevational view of a modified embodiment in accordance with the invention;
Figure 6 is a sectional view taken along line 6-6 of Figure 5;
Figure 7 is atop plan view of the modification of Figure 5;
Figure 8 is a top plan view of still another modified embodiment in accordance with this invention;
Figure 9 is an end view of the modification of Figure 8;
Figure 10 is a side elevational view of the modification of figure 8;
Figure 11 is a sectional view of yet another modified embodiment in accordance with this invention;
Figure 12 is atop plan view of the modification of Figure 11;
Figure 13 is a side elevational view of still another modified embodiment in accordance with this invention;
Figure 14 is an end view of the modification of Figure 13;
Figure 15 is a side elevational view of a component for use in accordance with this invention;
Figure 16 is a top plan view of the component of Figure 15;
Figure 17 is a bottom plan view of the component of Figure 15; and
Figure 18 is a diagrammatic section through a further embodiment in accordance with the invention

[0020] Referring now to the drawings, reference numeral 10 in Figure 1 generally identifies an arrangement for, and a method of, treating a fluid, e.g. water, contained in a conduit or water pipe 12 (shown in broken-away view) for the purpose of resisting and inhibiting the deposit of scale on the inner walls of the pipe 12, as well as for reversing the deposit of scale in pipe where scale has already built up.

[0021] In accordance with one preferred embodiment, a turbulence detector or microphone 14 is positioned in physical contact with the pipe, and is operative for detecting a sound that is generated as a result of turbulence inside the pipe. Such turbulence is generated as water passes through the pipe, especially when the water passes over lime scale deposits. An analog audio signal 16 is generated and has a frequency directly proportional to the amount of turbulence detected. The frequency lies in a range from 20 to 20,000 Hz.

[0022] A filter 18 is operative to remove noise from the audio signal 16, thereby filtering out sounds not associated with the turbulence of the water passing through the pipe. The filtered signal 20 is shown in figure 1.

[0023] A differential amplifier 22 processes and amplifies the filtered signal 20 in preparation for pulse shaping. The amplification has a gain, preferably adjustable, which is set sufficiently high to saturate the filtered signal 20 and convert the same to a saturated, squared signal 24.

[0024] A pulse shaping and differentiating network 26 processes the squared signal 24 to a series of pulses 28 of limited pulse widths. The frequency of the audio signal 16 is thus converted into a corresponding number of pulses.

[0025] A monostable multivibrator 30 expands the pulses 28 of limited width into a series of wider, digital pulses 32. A frequency to voltage converter, also known as an averager, preferably embodied by a capacitor 34, converts the wider pulses 32 to a DC voltage 36 whose amplitude is a function of the frequency of the wider pulses 32 and, hence, of the frequency of the audio signal. A voltage to pulse train converter or variable frequency astable multivibrator 38 converts the DC voltage 36 to a variable frequency train of pulses 40 whose frequency is also directly proportional to that of the audio signal. A power output transistor 42 converts the train of pulses 40 to a series of drive pulses that are conducted to a primary winding 44 of a high frequency output transformer 46 having a secondary winding 48 and an adjustable ferrite core 50 between the windings. Primary winding 44 is a tuned winding and is connected in series with a capacitor 52 and a DC supply voltage 54. The secondary winding 48 has a pair of spaced-apart terminals 56, 58 which, as described below, are placed into physical contact with the pipe 12 at a pair of contact zones spaced-apart lengthwise along the axis of the pipe.

[0026] The transformer 48 converts the drive pulses into a series of radio frequency ringing signals 60, each having a frequency in a range from 50 to 500 KHz and a generally sinusoidally varying amplitude diminishing from a maximum value to zero. The intervals between the ringing signals are not equal in duration, thereby providing a random wait state between the signals.

[0027] When the pipe is constituted of a conductive material, e.g. copper, the transformer 46 constitutes a low impedance source which is operative to generate a low voltage, high current signal between the terminals 56, 58. This high current travels along the pipe axis and generates an electromagnetic field (see Figures 4A, 4B) having generally circular magnetic lines of flux 62 in generally co-axial relation with the axis of the conduit. Between the terminals 56 and 58, the flux lines are co-axial with an imaginary line extending through the contact zones on the exterior of the pipe 12, since the pipe has a non-negligible diameter. The electromagnetic field shown in Figures 4A, 4B is shown for one instant of time, it being understood that this field expands and collapses as the amplitude of each ringing signal changes. A standing wave electric field is established over the length of the conduit, so that the radio frequency electromagnetic field propagates along the conduit in both directions both upstream and downstream of the contact zones and generates a descaling action on the water through the piping installation.

[0028] It has been observed that in the case of calcium carbonate scale, shorter wait states between the ringing signals reduces the time to occlusion of the conduit, whereas longer wait states increase the time to occlusion. Also, different temperatures and different wait states affect the occlusion rate. When other salts are in the water, different lengths of wait state may be desirable to have an effect on the crystallisation thereof. Hence randomly generated wait states (within certain limits) enable a wide range of different salts to be dealt with.

[0029] When the pipe is constituted of a non-conductive material, e.g. plastic, the same descaling action can be achieved by wrapping the section of the pipe between the contact zones with copper foil.

[0030] A power level indicator 64 serves as a visual display means, and is connected to the averager capacitor 34. The indicator 64 preferably comprises a series of light emitting diodes arranged in a row, the number of diodes lit at any one time being indicative ofthe level of output power.

[0031] As shown in Figure 2, the arrangement 10 is housed in a housing 66 connected by plastic ties or holders 68 to the pipe. the terminals 56, 58 are externally located on the housing and are pressed into electro-mechanical contact with the pipe when the housing is held thereon. The microphone is located within the housing together with all the other components depicted in Figure 1. The display 64 is also exteriorly located on the housing for easy viewing. Electrical power is supplied to the housing via cable 70. Each of the aforementioned terminals 56, 58 is preferably comprised of a pair of terminal portions (see 58a, 58b in Figure 3) on both of which the pipe 12 rests to resist accidental slippage from the pipe. External controls on the housing may be employed to manually adjust interior components.

[0032] Turning to Figures 5 through 7, rather than using a transformer having a secondary winding, the same electromagnetic field can be achieved in a more efficient manner in accordance with the invention with a novel device operative to make the pipe itself and/or the water therein serve as the secondary winding. A primary winding 72 of electrical wire is coiled in a loop about a first axis 74 (see Figure 7). Each coil of the primary winding 72 lies in a plane extending lengthwise along the axis of the pipe 12. The primary winding is mounted on a spool 76 mounted exteriorly of the pipe. A magnetic core 78 of ferrite or other suitable material of high permeability magnetic properties is coiled spirally around the pipe about the pipe axis. The ferrite core 78 extends through each coil of the primary winding 72. The ferrite core can consist of a number of rigid links or, as shown, as a flexible strip similar to the type used in strip magnets on refrigerator doors. This arrangement forms a toroidal transformer in which the pipe itself is the secondary winding of the transformer. The toroidal transformer is more efficient than the lower efficiency transformer 46 described in connection with Figure 1, and is of special benefit on large diameter pipes. The toroidal transformer has a larger primary to secondary ratio which matches the impedance of the source directly to the pipe.

[0033] The direction and current concentration of the AC current generated in the pipe and in the water is depicted in Figure 6. The circle with the dot and the + sign respectively represent the direction of the AC current flowing toward and away from the viewer. The AC current is uniformly distributed and concentrated around the periphery of the pipe due to the well known "skin effect". It will be noted that the pipe does not have to be constituted of a metal material, nor need plastic pipe be wrapped with metal foil, as described above, because in the arrangement of Figures 5 through 7, the liquid itself acts as a conductor and secondary coil of the toroidal transformer. A standing wave electric field is established throughout the liquid in the pipe. No contact points are required along the pipe, to ensure a more reliable operation over long periods of time without the need for maintenance.

[0034] Another way of making the primary winding is to use a multi-wire ribbon cable 80 depicted in Figures 8 through 10. Cable 80 has a pin connector 82 and a socket connector 84 at opposite ends of the cable. Pin connector 82 has a row of pins projecting therefrom; and socket connector 84 has a row of sockets formed therein. The number of pins and sockets correspond to the number of individual conductors within the cable.

[0035] In order to form a continuous coil out of the individual conductors in the cable 80, the pin and socket connector are interconnected, with one pin 86 (see Figure 8) offset, In other words, the second pin in the row is connected to the first socket, the third pin in the row is connected to the second socket, and so on. The first pin 86 and the last socket are left unconnected, thereby forming a continuous loop when the connectors are so interconnected.

[0036] Otherwise, a ferrite core 88 is, as described above, coiled about pipe 12 and is routed through the cable 80. Again, the pipe itself and/or the water therein serve as the secondary winding for the toroidal transformer.

[0037] Still another way of making the primary winding is, as shown in Figures 11 and 12, to use a dual in-line package 96 having two rows of pins 97 extending from opposite sides of the package, as well as a printed circuit board 92 having corresponding rows of sockets therein for receiving the pins. A generally U-shaped ferrite core 94 extends around the underside of the conduit 12, through the board and continues along core section 95 between the package 96 and the board 92. As before, the package is mounted on the board with the rows offset so that one pin of each row of a the package is offset from the corresponding row of sockets, thereby forming a continuous loop. The pipe itself and/or the water therein serves as the secondary winding of the transformer thus formed.

[0038] As shown in Figures 13 and 14, a ferrite core 100 surrounds the pipe 12. A plurality of cables 101 are routed between the pipe and the core 100. Opposite cable ends 105, 106 are connected to a housing 102 mounted to the pipe in a similar manner to that shown in Figure 2. A dual-in-line package 104 and printed circuit board 103, analogous to package 96 and board 92, are shown.

[0039] Figure 15 depicts another dual-in-line package 110, similar to package 96. Package 110 has two rows of a pins 111, a permanent ferrite core 107, and an optional C-shaped core 108. Package 110 is mounted on a printed circuit board 109. Pins 111 are mounted in corresponding sockets on the board, with the rows offset from the sockets as previously described in connection with Figures 11 and 12.

[0040] The pins 111 are part of a U-shaped winding which is completed by conductive tracks 112 shown an the underside of the board 109 in Figure 17. The ratio between the primary coil of which the pins 111 and tracks 112 form part and the secondary coil of which further tracks 114 form part, can be adjusted. Tap points can be added where desired.

[0041] Referring now to Figure 18 of the drawings, this illustrates an especially convenient arrangement of the housing and some of the operative components of an apparatus in accordance with the invention, which renders it particularly simple to apply to a pipe or conduit for treating liquid within the pipe or conduit.

[0042] The apparatus shown in Figure 18 comprises a housing assembly 120 having two housing sub-assemblies 121, 122. The sub-assemblies 121, 122 are of hollow configuration each comprising two components which preferably are mouldings of plastics material, assembled to one another to meet at a joining line which is the sectional plane of the drawing and defining respective internal cavities 123, 124. Within the internal cavity 123 of the sub-assembly 121 there is disposed a generally U-shaped core part 125 of ferrite or other material of a like magnetic properties, and within the internal cavity 124 of subassembly in there is disposed a further generally U-shaped core part 126. The limbs of the core parts 125, 126 end in flat surfaces which abut one another at 127 and 128 so that the core establishes a magnetic circuit in the form of a closed loop or annulus.

[0043] The limbs of the core part 125 extend within hollow spigot portions indicated generally at 129 of the housing sub-assembly 121. The hollow spigot portions 129 terminate in bead formations 130. The limbs of the core part 126 extend within hollow spigot portions indicated generally at 131 of the casing sub-assembly 122, and the spigot portions 131 terminate in clip formations 132 engageable with the bead formations 130 at the ends of the spigot parts 129 which face them. Thus the two casing sub-assemblies are able to be snap-fitted together. A leaf spring 142 disposed between the core part 126 and a wall portion of the housing sub-assembly 122 biases the core part 126 into abutment with the core part 125, with sufficient force to ensure that no substantial air gap can open between the core parts and thereby interrupt the magnetic circuit provided by the core.

[0044] When thus fitted together, the two housing sub-assemblies define an opening 133 through which a pipe or conduit can extend with the core disposed circumferentially around the pipe or conduit. Fastening means may be provided for ensuring the casing remains at the required position on the pipe or conduit.

[0045] The interior cavity 123 of the housing sub-assembly 121 is of sufficient dimensions to accommodate the electrical and electronic components above described, including a primary coil through which the core part 125 extends, for establishing an electromagnetic field as above described in a fluid contained within the pipe or conduit which passes through the opening 133.

[0046] The conditioner is especially useful for treating water in domestic or commercial water supply systems or heating systems and can be beneficially used in water treatment stations or swimming pools. The conditioner need not be restricted to treating water, but can also treat beer in barrels, sewage in settling tanks, wine in fermenting vessels, fuel in fuel tanks and in short, any fluid having ions or fine suspended solids therein

[0047] As above referred to, the invention is useful in fields Other than or in addition to the treatment of water in order to resist the build up of scale deposits in a water system. The invention has an effect on biological conditions in fluid, for example the growth of algae or bacteria in fresh or sea water may be affected when the water is treated in accordance with the invention. Further, the invention has been found to have an effect on a flocculation process; in a system treated in accordance with the invention the floc settled more quickly than when untreated.

[0048] The invention has also been found to have an effect on crystal growth generally, in fields other than the deposition of scale. When crystals are grown from a solution treated in accordance with the invention, crystal size and the extent of hydration of these crystals are affected. Further, some chemical reactions involving ions and/or free radicals as intermediates are affected by treatment in accordance with the invention.

[0049] The invention has also been found to have an effect on chlorine treatment of water, e.g. for a swimming pool. When treated in accordance with the invention, the fixation of chlorine in the water has been affected, so that the requirement for regular addition of chlorine to maintain the required concentration thereof has been reduced.

[0050] Further, the invention has also been found to have an effect on corrosion in a water system. Corrosion of metal pipes, particularly ferrous metal pipes, carrying water has been found to be reduced in a system treated in accordance with the invention.

[0051] It is believed that the advantageous effect on corrosion of such metal pipes is because the reactions which take place when corrosion occurs require the presence of free electrons in the water. In response to the electromagnetic field created in accordance with the invention, the free electrons are urged away from the centre of the pipe towards the metal pipe surrounding the liquid, where a similar charge is carried by the pipe. The electrons are repelled to a narrow band around the pipe circumference but away from the metal, removing them from the zone where corrosion reactions take place and thereby preventing or at least inhibiting corrosion.

[0052] Further potential uses for the invention are as a non-intrusive conductivity meter or flow meter, for the detection of buried plastics pipes, for the detection of leaks in distribution networks, and for the differentiation between gas- and water-carrying metal pipes.

[0053] It will be understood that each of the elements described above, or two or more together, also may find a useful application in other types of constructions differing from the types described above.

[0054] While the invention has been illustrated and described as embodied in arrangement for and method of conditioning water, it is not intended to be limited to the details shown, since various modifications and structural changes may be made while remaining within the scope of the claims.

Claims

1. Apparatus for treating a fluid contained in a conduit (12) extending along an axis, comprising means for generating radio frequency signals, and means; for applying said signals to the fluid in the conduit, characterised in that said means for applying the signals comprises:

   a primary coil (72; 80; 96, 97; 101; 111,112) mounted to the exterior of the conduit;
   means for energising the primary coil with the radio frequency signals; and
   a core (78; 88; 94; 100; 107; 125,126) of magnetically permeable material extending around the conduit and through the primary coil, for generating in the fluid to be treated an electromagnetic field having substantially circular magnetic flux lines in substantially co-axial relation with the axis of the conduit, and for propagating the field along the axis to treat the fluid upstream and downstream of the primary coil.

2. Apparatus according to Claim 1 further characterised in that said core is of a ferrite material.

3. Apparatus according to Claim 1 or Claim 2 further characterised in that each said radio frequency signal has a frequency in a range from 50 to 500 KHz, and has a sinusoidally variable amplitude diminishing from a maximum value to zero.

4. Apparatus according to any one of the preceding claims further characterised in that there are wait states of random length between successive radio frequency signals.

5. Apparatus according to any one of the preceding claims further characterised in that the primary coil (80) comprises a winding of electrical wire, afforded

by a multi-wire ribbon cable having a pin connector (82, 84) and a socket connector at opposite ends of the cable, the pin connector having a row of pins and the socket connector having a row of sockets and wherein the connectors are interconnected to form a loop with the rows offset by one pin.

6. Apparatus according to any one of Claims 1 to 4 further characterised in that the primary coil includes a dual in-line package (96) having a row of pins, and a printed circuit board (92) having a row of sockets, and wherein the package is mounted on the board with the rows offset by one pin, whereby the energising means is connected to the primary coil.

7. Apparatus according to any one of the preceding claims further characterised in that said core comprises a number of rigid links connected to one another.

8. Apparatus according to any one of Claims 1 to 6 further characterised by a housing (120) having respective parts (121, 122) each containing a part (125, 126) of said core, said housing parts being connectable together to embrace the conduit and such that said core parts define the core extending around the conduit.

9. Apparatus according to Claim 8 further characterised in that said housing parts comprise respective fastening formations (130, 132) interengagable to hold said housing parts together to embrace the conduit.

10. Apparatus according to Claim 9 further characterised in that said fastening formations (130, 132) are snap-engageable with one another.

11. Apparatus according to any one of Claims 8 to 10 further characterised by spring means for urging said core parts into engagement with one another.

12. Apparatus according to any one of the preceding claims, further characterised in that the energising means includes means for detecting sound of fluid flowing along the conduit, and for generating an analog audio signal having a frequency proportional to the detected sound.

13. Apparatus according to Claim 12, further characterised in that the energising means includes means for removing noise from the audio signal, means for converting the audio signal into a series of digital pulses whose frequency is proportional to the frequency of the audio signal, means for converting the digital pulses to a DC voltage whose amplitude is proportional to the frequency of the audio signal, and means for changing the DC voltage to a train of drive pulses applied to the primary coil.

14. A method of treating a fluid in a conduit extending along an axis, by generating radio frequency signals and applying said signals to the fluid in the conduit, characterised in that said signals are applied to the fluid by:-

mounting a primary coil at the exterior of the conduit;
energising the primary coil with the radio frequency signals; and
providing a core of a magnetically permeable material extending around the conduit and through the primary coil, whereby an electromagnetic field having substantially circular magnetic flux lines in substantially co-axial relation with the axis of the conduit is established and the field is propagated along the axis to treat the fluid upstream and downstream of the primary coil.

Patentansprüche

1. Vorrichtung zur Behandlung einer Flüssigkeit, die in einer Leitung (12) enthalten, die sich entlang einer Achse ausbreitet, wobei die Vorrichtung ein Mittel zum Erzeugen von Radiofrequenzsignalen und ein Mittel zum Anlegen dieser Signale an die Flüssigkeit in der Leitung umfaßt, dadurch gekennzeichnet, daß das Mittel zum Anlegen der Signale folgendes umfaßt:

eine Primärspule (72; 80; 96, 97; 101; 111; 112), die an dem Äußeren der Leitung angebracht ist,
ein Mittel zum Anregen der Primärspule mit den Radiofrequenzsignalen; und
einen Kern (78; 88; 94; 100; 107; 125; 126) aus magnetisch permeablem Material, der sich um die Leitung und durch die Primärspule hindurch erstreckt, um in der zu behandelnden Flüssigkeit ein elektromagnetisches Feld zu erzeugen, das im wesentlichen kreisförmige Magnetflußlinien in im wesentlichen koaxialer Beziehung zu der Achse der Leitung aufweist, und um das Feld entlang der Achse vorzutreiben, um die Flüssigkeit stromaufwärts und stromabwärts der Primärspule zu behandeln.

2. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß der Kern aus einem Ferritmaterial besteht.

3. Vorrichtung nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß jedes Radiofrequenzsignal eine Frequenz in einem Bereich von 50 bis 500 KHz und

eine sinusförmige, variable Amplitude, die sich von einem maximalen Wert auf Null reduziert, aufweist.

4. Vorrichtung nach irgendeinem der vorangehenden Ansprüche, dadurch gekennzeichnet, daß Wartezustände von beliebiger Länge zwischen aufeinanderfolgenden Radiofrequenzsignalen bestehen.

5. Vorrichtung nach irgendeinem der vorangehenden Ansprüche, dadurch gekennzeichnet, daß die Primärspule (80) eine Windung aus Elektrodraht umfaßt, dargeboten von einem Mulitdrahtbandkabel, das ein Stiftverbindungsglied (82; 84) und ein Steckerverbindungsglied an gegenüberliegenden Enden des Kabels aufweist, wobei das Stiftverbindungsglied eine Reihe von Stiften und das Steckerverbindungsglied eine Reihe von Steckern aufweist und die Verbindungsglieder miteinander verbunden sind, um eine Schleife zu bilden, wobei die Reihen um einen Stift versetzt sind.

6. Vorrichtung nach irgendeinem der Ansprüche 1 bis 4, dadurch gekennzeichnet, daß die Primärspule eine duale In-line-Packung (96), die eine Reihe von Stiften aufweist, und eine Leiterplatte (92), die eine Reihe von Steckern aufweist, enthält, und daß die Packung auf der Platte aufgebracht ist, wobei die Reihen um einen Stift versetzt sind, wodurch das Anregungsmittel mit der Primärspule verbunden ist.

7. Vorrichtung nach irgendeinem der vorangehenden Ansprüche, dadurch gekennzeichnet, daß der Kern eine Reihe von steifen Verbindungselementen umfaßt, die miteinander verbunden sind.

8. Vorrichtung nach irgendeinem der Ansprüche 1 bis 6, gekennzeichnet durch ein Gehäuse (120), das entsprechende Teile (121, 122) aufweist, die jeweils einen Teil (125, 126) des Kerns enthalten, wobei die Gehäuseteile miteinander verbindbar sind, um die Schaltung und somit die Kernteile, die den Kern festlegen, der sich um die Leitung herum erstreckt, zu umfasssen.

9. Vorrichtung nach Anspruch 8, dadurch gekennzeichnet, daß die Gehäuseteile entsprechende Befestigungseinrichtung (130, 132) umfassen, die miteinander in Eingriff bringbar sind, um die Gehäuseteile zusammenzuhalten, um die Leitung zu umfassen.

10. Vorrichtung nach Anspruch 9, dadurch gekennzeichnet, daß die Befestigungseinrichtungen (130, 132) ineinander einschnappbar sind.

11. Vorrichtung nach irgendeinem der Ansprüche 8 bis 10, gekennzeichnet durch ein Federmittel zum Zwingen der Kernteile in Eingriff miteinander.

12. Vorrichtung nach irgendeinem der vorangehenden Ansprüche, dadurch gekennzeichnet, daß das Anregungsmittel ein Mittel zum Erfassen von Schall von Flüssigkeit, die entlang der Leitung fließt, und zum Erzeugen eines analogen Audiosignals, das eine Frequenz aufweist, die proportional zu dem erfaßten Schall ist, enthält.

13. Vorrichtung nach Anspruch 12, dadurch gekennzeichnet, daß das Anregungsmittel ein Mittel zum Entfernen von Rauschen aus dem Audiosignal, ein Mittel zum Umwandeln des Audiosignals in eine Reihe von digitalen Impulsen, deren Frequenz proportional zu der Frequenz des Audiosignals ist, ein Mittel zum Umwandeln der digitalen Impulse in eine DC-Spannung, deren Amplitude proportional zu der Frequenz des Audiosignals ist, und ein Mittel zum Ändern der DC-Spannung in eine Anzahl von Antriebs impulsen, die an die Primärspule angelegt werden, enthält.

14. Verfahren zum Behandeln einer Flüssigkeit in einer Leitung, die sich entlang einer Achse erstreckt, durch Erzeugen von Radiofrequenzsignalen und Anlegen dieser Signale an die Flüssigkeit in der Leitung, dadurch gekennzeichnet, daß die Signale an die Flüssigkeit wie folgt angelegt werden:

- Anbringen einer Primärspule an das Äußere der Leitung;
- Anregen der Primärspule mit den Radiofrequenzsignalen; und
- Bereitstellen eines Kerns aus magnetisch permeablem Material, der sich um die Leitung und durch die Primärspule hindurch erstreckt, wodurch ein elektromagnetisches Feld, das im wesentlichen kreisförmige Magnetflußlinien in im wesentlichen koaxialer Beziehung zu der Achse der Leitung ausweist, aufgebaut wird und das Feld entlang der Achse fortschreitet, um die Flüssigkeit stromaufwärts und stromabwärts der Primärspule zu behandeln.

Revendications

1. Dispositif destiné à traiter un fluide contenu dans un conduit (12) s'étendant le long d'un axe, comprenant un moyen destiné à produire des signaux à fréquence radio, et un moyen destiné à appliquer lesdits signaux au fluide dans le conduit, caractérisé en ce que ledit moyen destiné à appliquer les signaux comprend :

une bobine primaire (72 ; 80 ; 96, 97 ; 101 ; 111, 112) montée à l'extérieur du conduit ;
un moyen destiné à exciter la bobine primaire avec les signaux à fréquence radio ; et

un noyau (78 ; 88 ; 94 ; 100 ; 107 ; 125, 126) constitué d'un matériau magnétiquement perméable s'étendant autour du conduit et à travers la bobine primaire, destiné à produire dans le fluide à traiter un champ électromagnétique ayant des lignes de flux magnétique sensiblement circulaires selon une relation sensiblement coaxiale à l'axe du conduit, et destiné à propager le champ le long de l'axe, de façon à traiter le fluide en amont et en aval de la bobine primaire.

2. Dispositif selon la revendication 1, caractérisé en outre en ce que ledit noyau est en ferrite.

3. Dispositif selon la revendication 1 ou la revendication 2, caractérisé en outre en ce que ledit signal à fréquence radio a une fréquence dans une plage de 50 à 500 KHz, et a une amplitude variable sinusoïdale diminuant d'une valeur maximale à une valeur nulle.

4. Dispositif selon l'une quelconque des revendications précédentes, caractérisé en outre en ce qu'il existe des états d'attente de longueur aléatoire entre des signaux à fréquence radio successifs.

5. Dispositif selon l'une quelconque des revendications précédentes, caractérisé en outre en ce que la bobine primaire (80) comprend un enroulement de fil électrique, constitué par un câble-ruban multifils comportant un connecteur mâle (82, 84) et un connecteur femelle aux extrémités opposées du câble, le connecteur mâle comportant une rangée de broches et le connecteur femelle comportant une rangée de douilles, et dans lequel les connecteurs sont interconnectés de façon à former une boucle avec les rangées décalées d'une broche.

6. Dispositif selon l'une quelconque des revendications 1 à 4, caractérisé en outre en ce que la bobine primaire comprend un boîtier intégré double (96) comportant une rangée de broches, et une carte de circuit imprimé (92) comportant une rangée de douilles, et dans lequel le boîtier est monté sur la carte avec les rangées décalées d'une broche, ce par quoi le moyen d'excitation est relié à la bobine primaire.

7. Dispositif selon l'une quelconque des revendications précédentes, caractérisé en outre en ce que ledit noyau comprend un certain nombre de tiges de liaison rigides reliées les unes aux autres.

8. Dispositif selon l'une quelconque des revendications 1 à 6, caractérisé en outre par un boîtier (120) comportant des parties respectives (121, 122) contenant chacune une partie (125, 126) dudit noyau, lesdites parties de boîtier pouvant être reliées ensemble de façon à entourer le conduit, et de sorte que lesdites parties de noyau définissent le noyau qui s'étend autour du conduit.

9. Dispositif selon la revendication 8, caractérisé en outre en ce que lesdites parties de boîtier comprennent des conformations de fixation respectives (130, 132) pouvant s'interpénétrer, destinées à maintenir ensemble lesdites parties de boîtier afin d'entourer le conduit.

10. Dispositif selon la revendication 9, caractérisé en outre en ce que lesdites conformations de fixation (130, 132) peuvent s'interpénétrer l'une l'autre par encliquetage.

11. Dispositif selon l'une quelconque des revendications 8 à 10, caractérisé en outre par un moyen formant ressort destiné à solliciter lesdites parties de noyau pour qu'elles coopèrent l'une avec l'autre.

12. Dispositif selon l'une quelconque des revendications précédentes, caractérisé en outre en ce que le moyen d'excitation comprend des moyens destinés à détecter le son du fluide s'écoulant le long du conduit, et à produire un signal audio analogique dont la fréquence est proportionnelle au son détecté.

13. Dispositif selon la revendication 12, caractérisé en outre en ce que le moyen d'excitation comprend un moyen destiné à supprimer tout bruit du signal audio, un moyen destiné à convertir le signal audio en une série d'impulsions numériques dont la fréquence est proportionnelle à la fréquence du signal audio, un moyen destiné à convertir les impulsions numériques en une tension continue dont l'amplitude est proportionnelle à la fréquence du signal audio, et un moyen destiné à changer la tension continue en un train d'impulsions d'attaque appliqué à la bobine primaire.

14. Procédé de traitement d'un fluide dans un conduit s'étendant le long d'un axe, en produisant des signaux à fréquence radio et en appliquant lesdits signaux au fluide dans le conduit, caractérisé en ce que lesdits signaux sont appliqués au fluide en suivant les étapes consistant à :

monter une bobine primaire à l'extérieur du conduit ;
exciter la bobine primaire avec les signaux à fréquence radio ; et à
prévoir un noyau constitué d'un matériau magnétiquement perméable s'étendant autour du conduit et à travers la bobine primaire, ce par quoi un champ électromagnétique ayant des li-

gnes de flux magnétique sensiblement circulaires selon une relation sensiblement coaxiale à l'axe du conduit est établi, et le champ est propagé le long de l'axe de façon à traiter le fluide en amont et en aval de la bobine primaire.

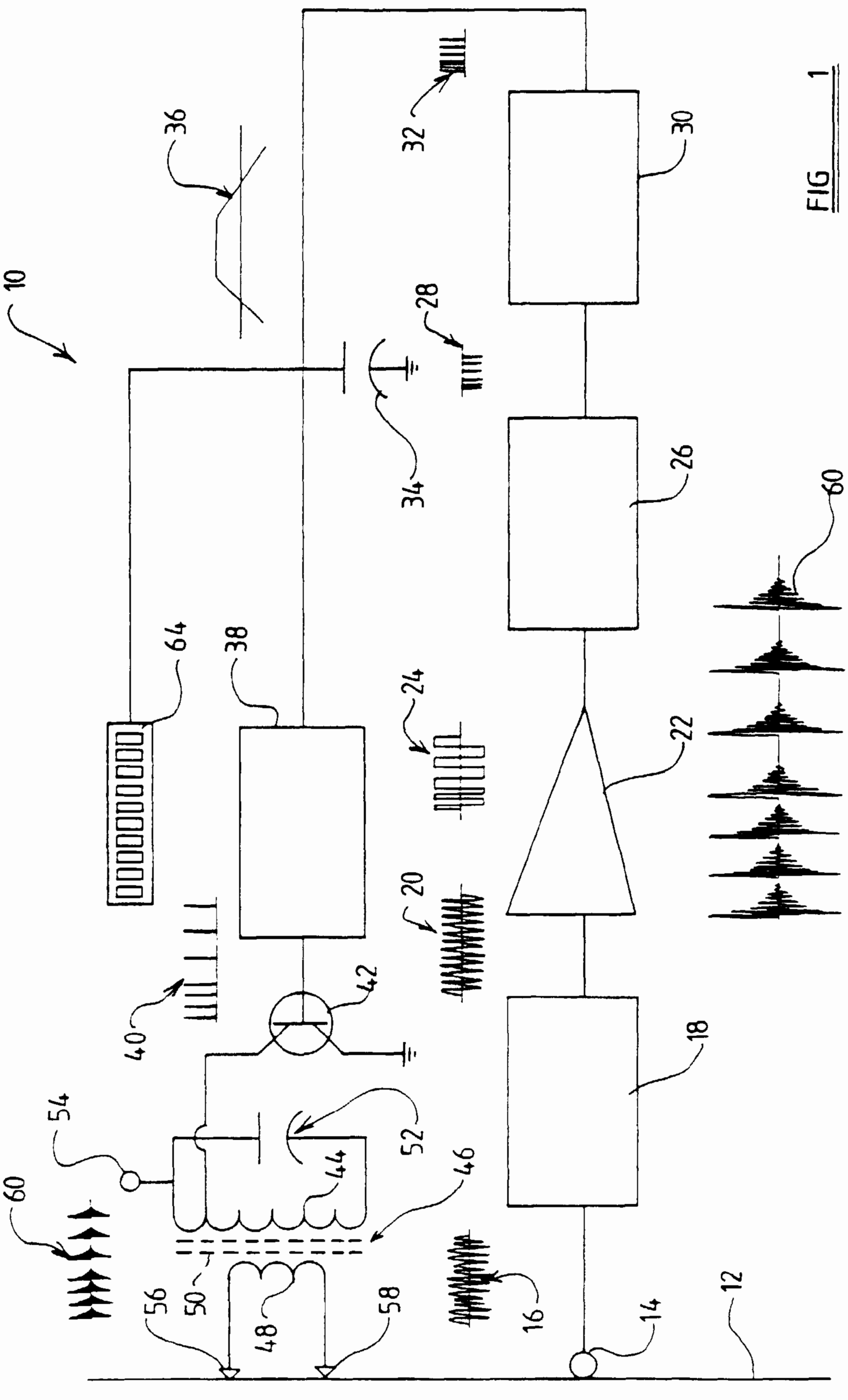
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FIG 1

FIG 2

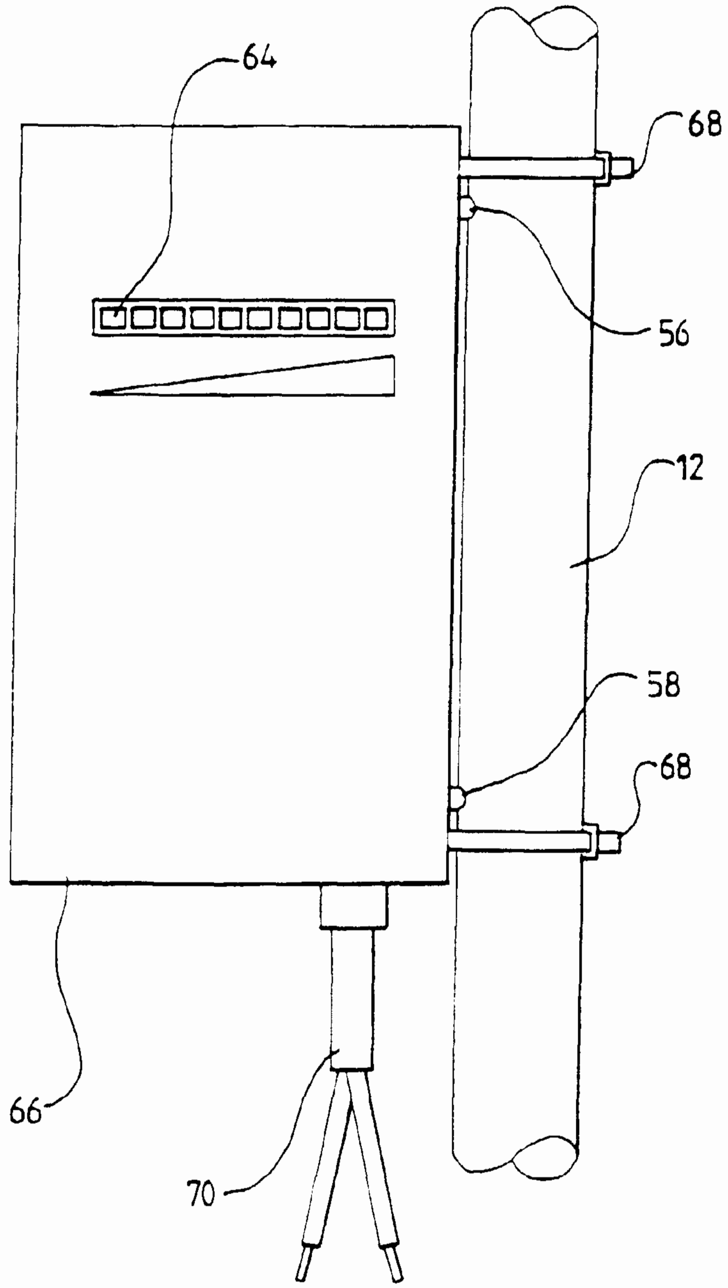
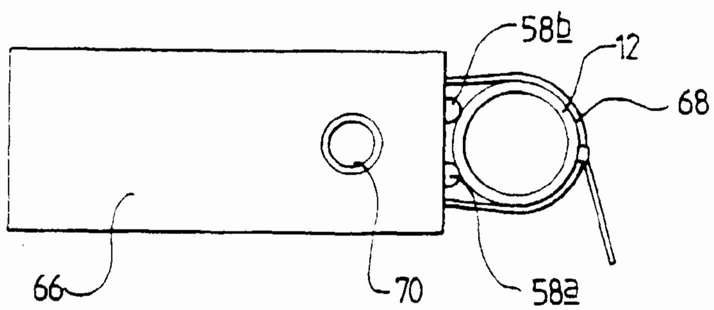


FIG 3



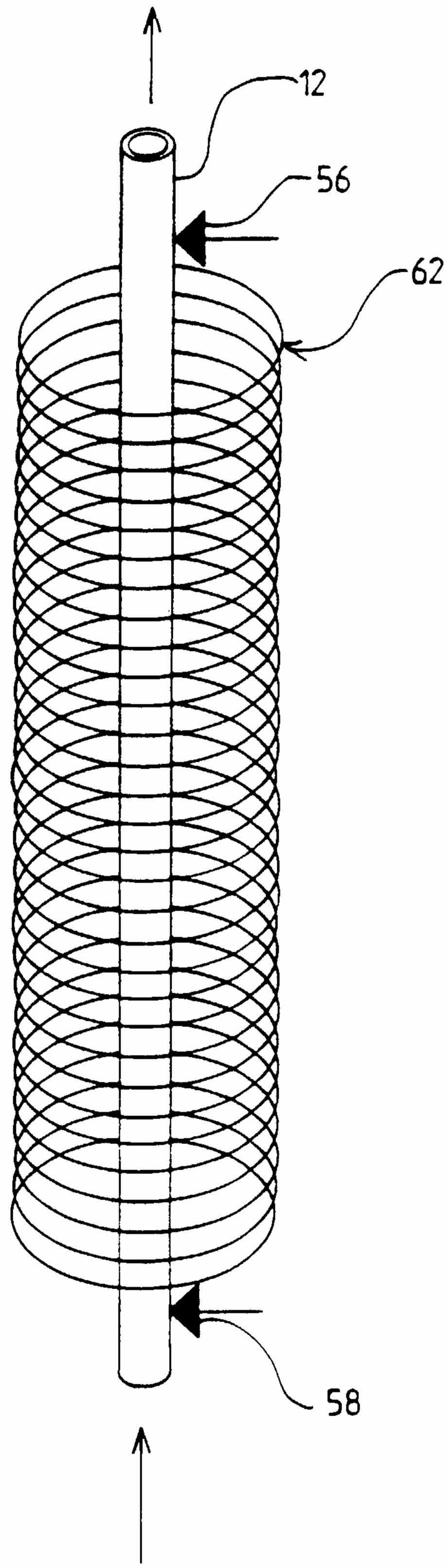


FIG 4A

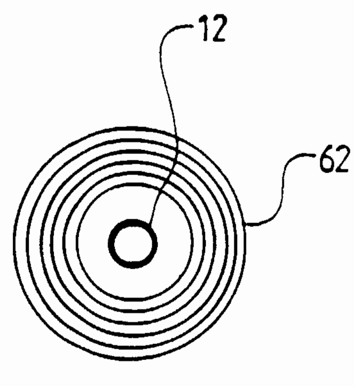


FIG 4B

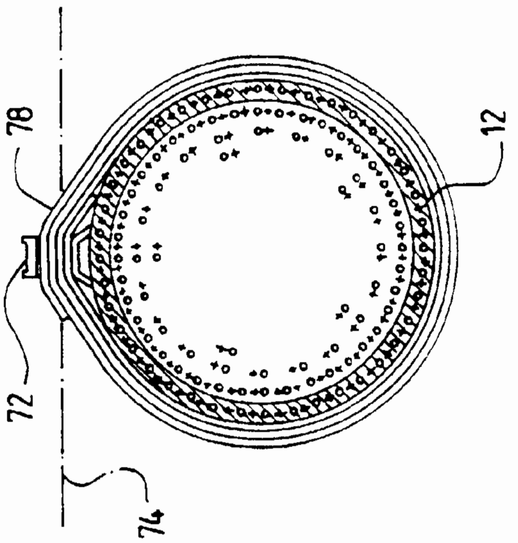


FIG 6

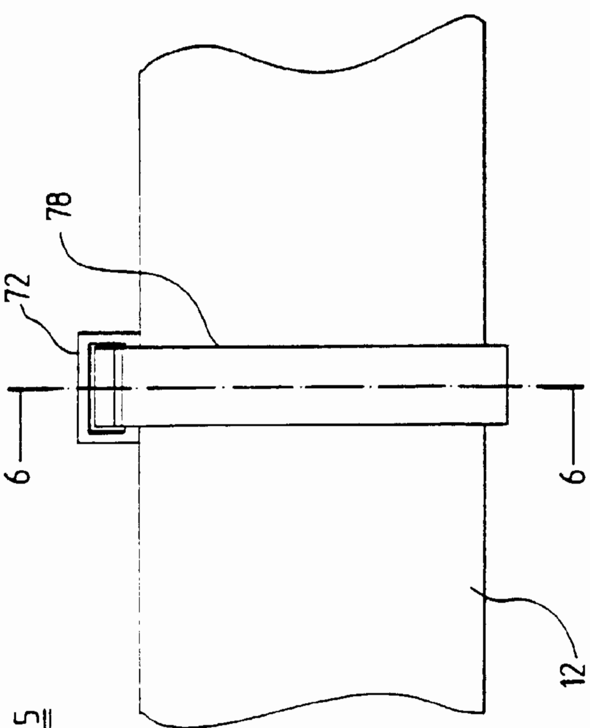


FIG 5

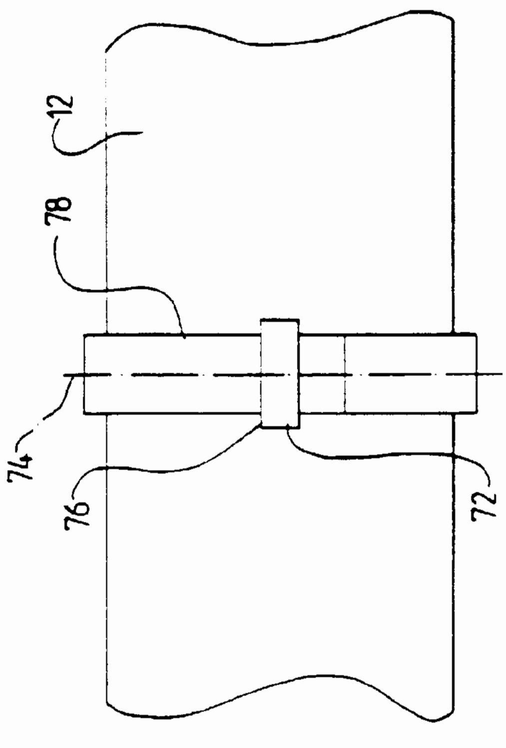


FIG 7

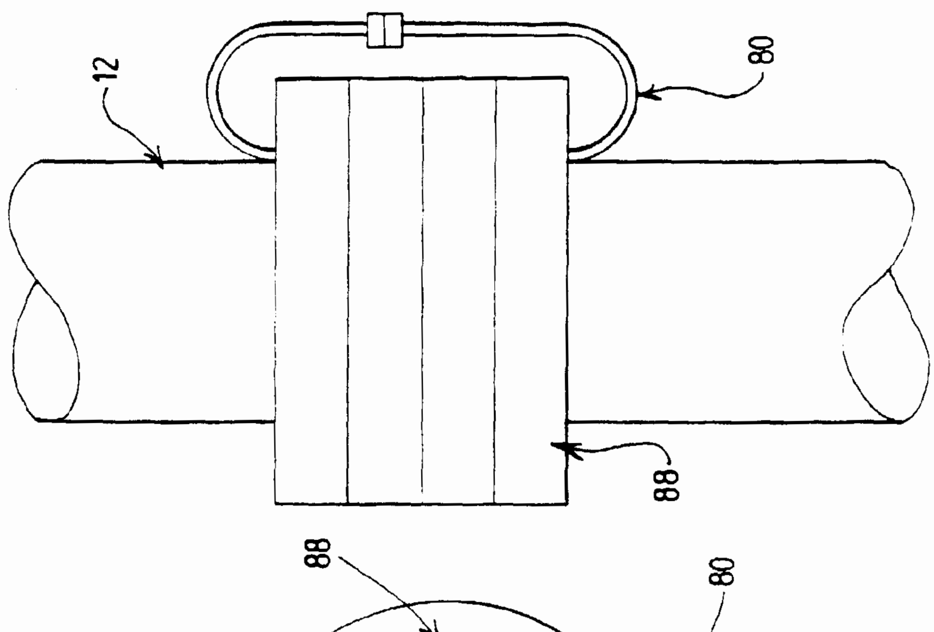


FIG 10

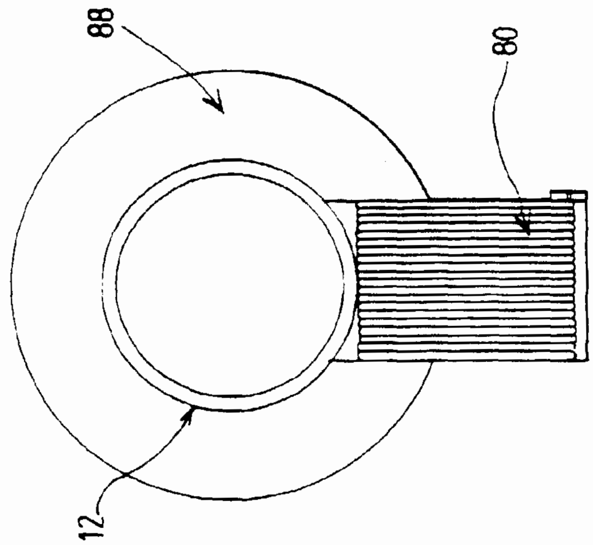


FIG 9

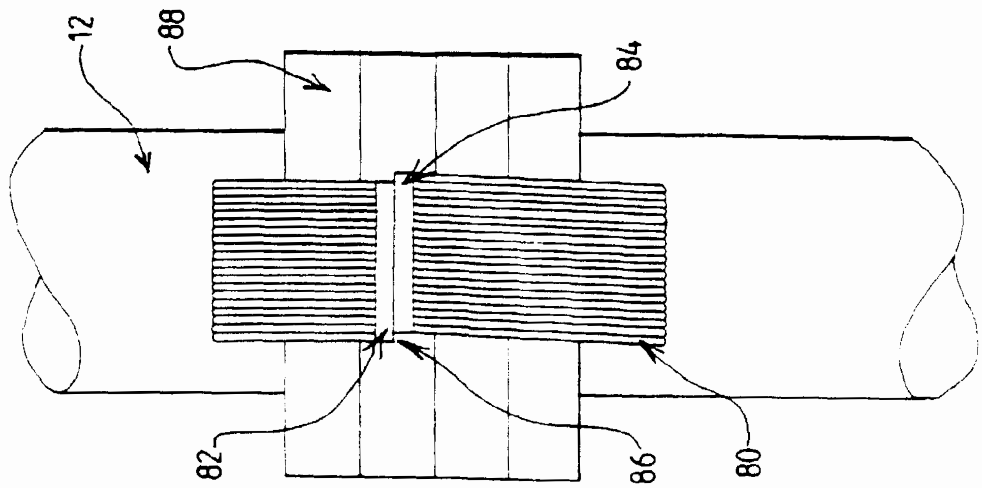


FIG 8

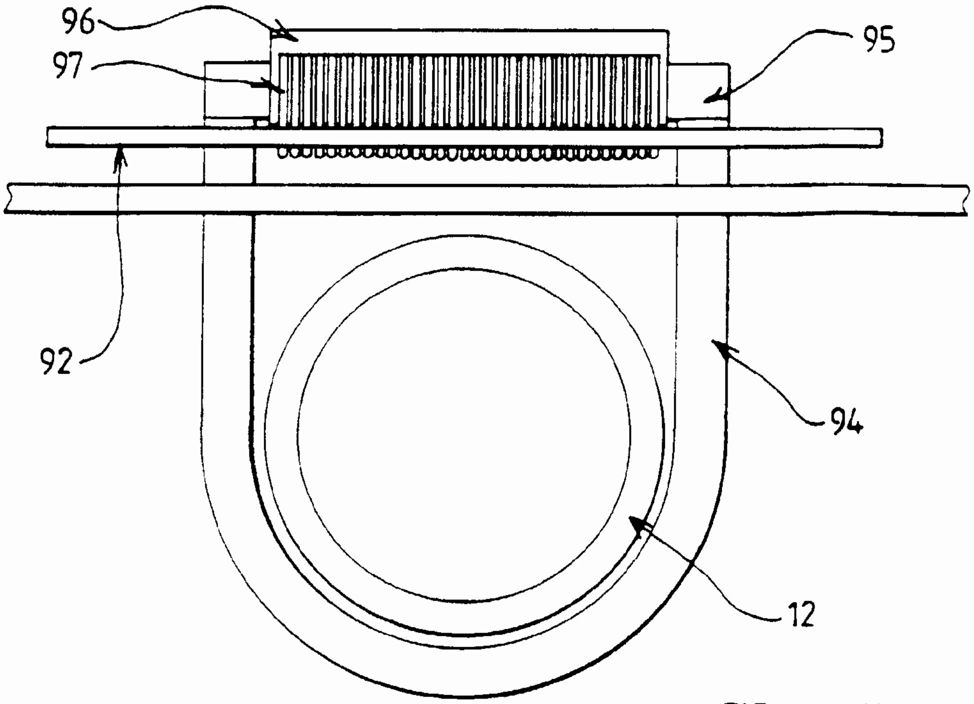


FIG 11

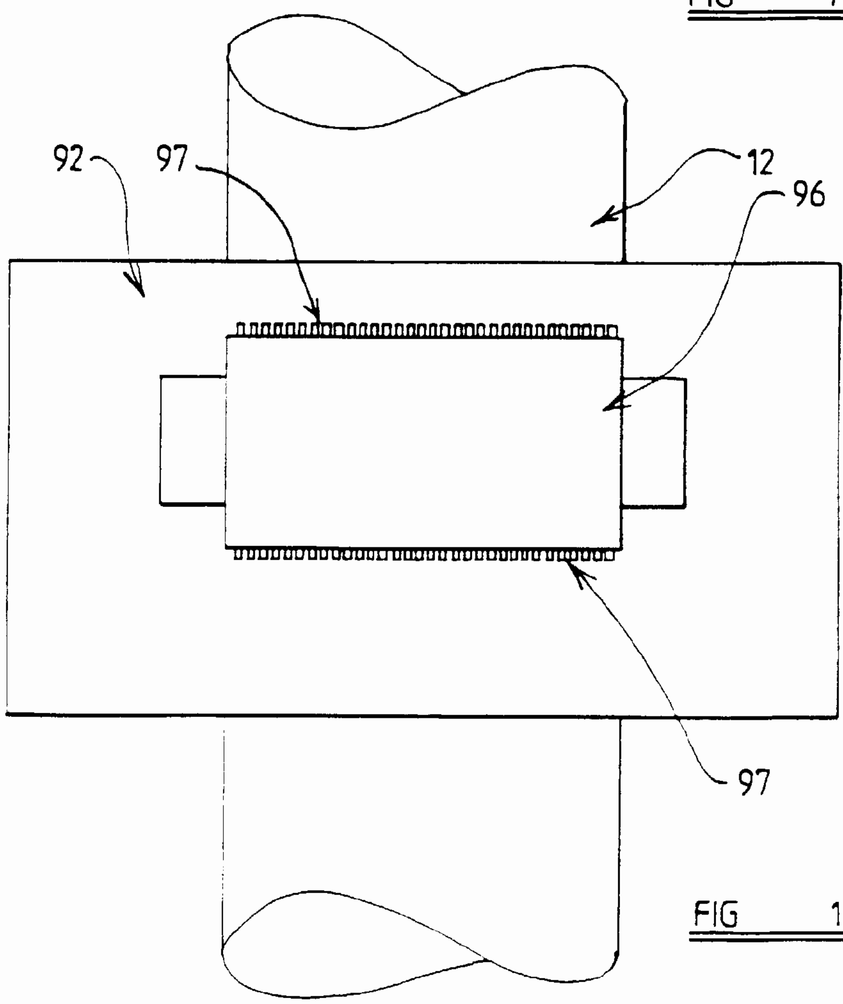


FIG 12

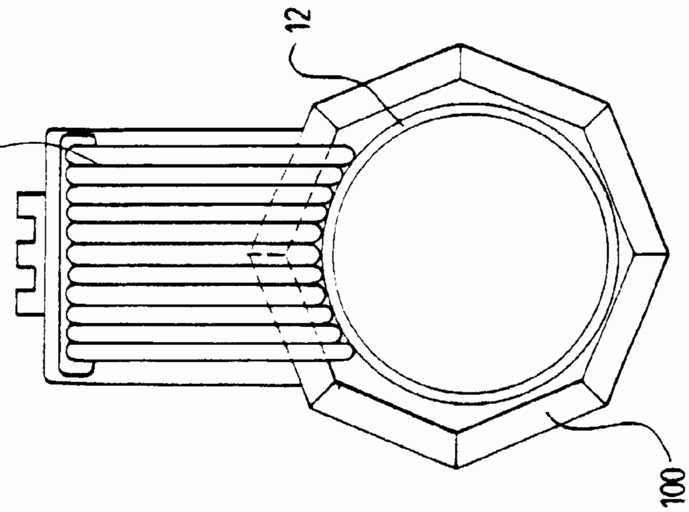


FIG 14

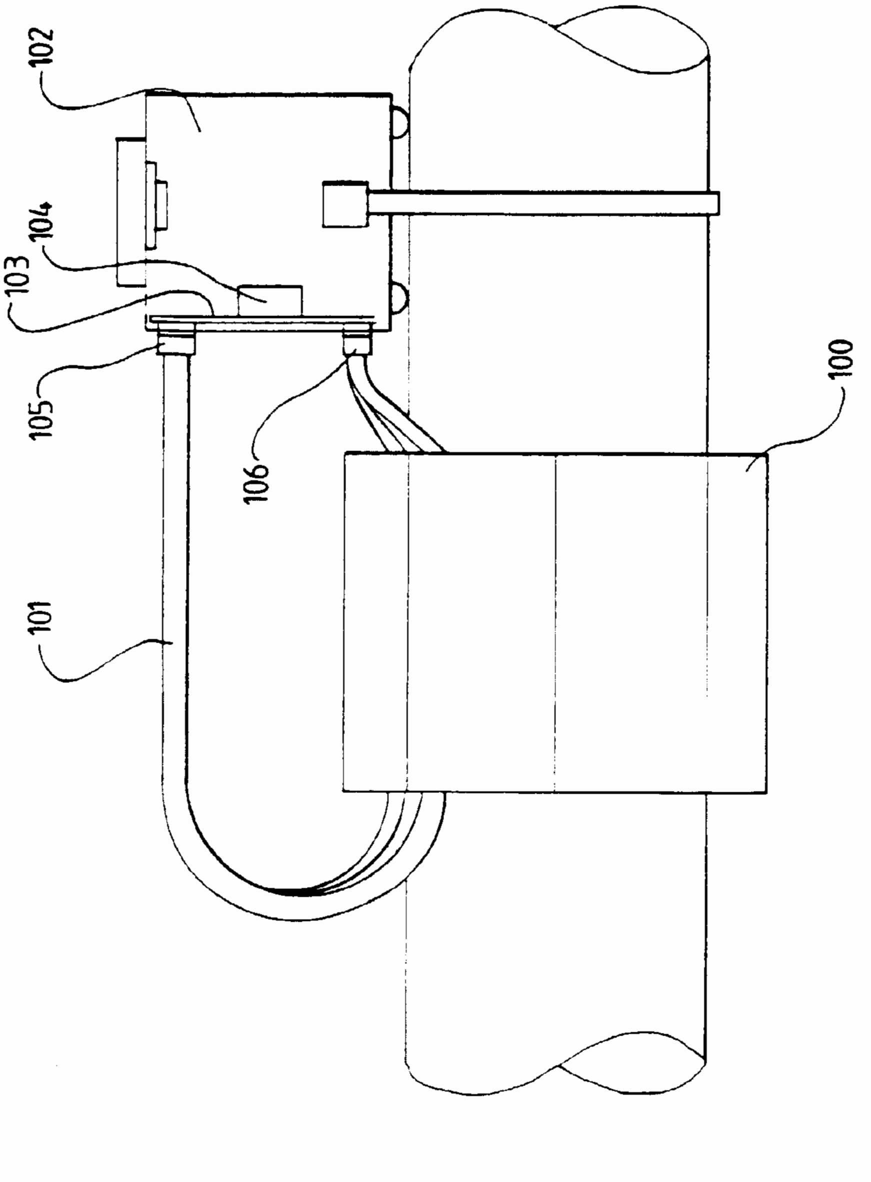


FIG 13

FIG 15

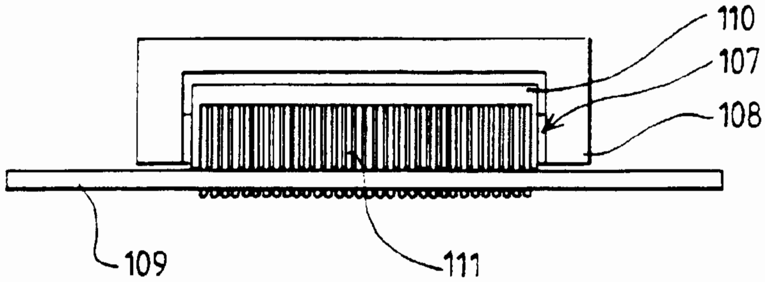


FIG 16

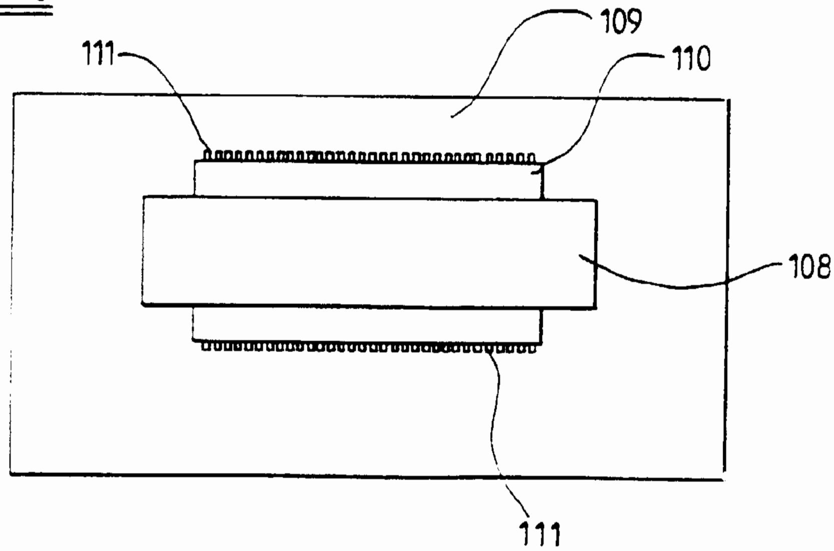
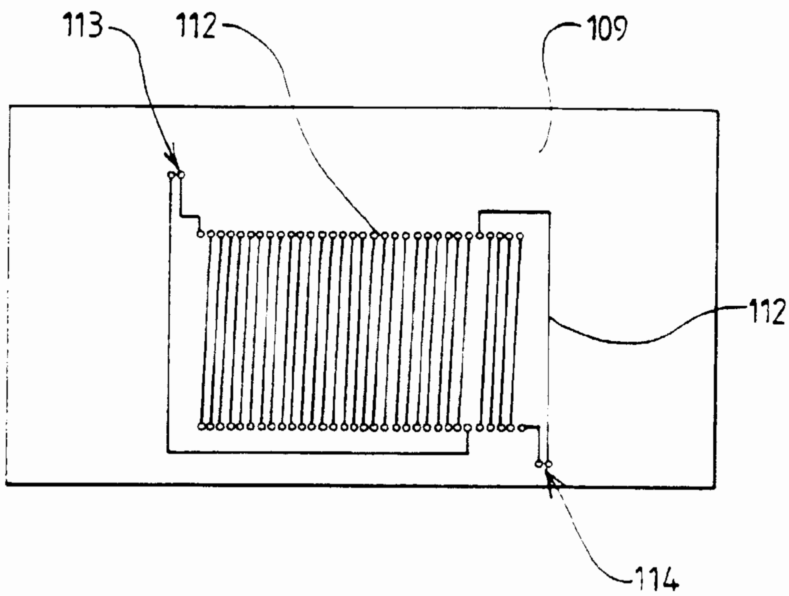


FIG 17



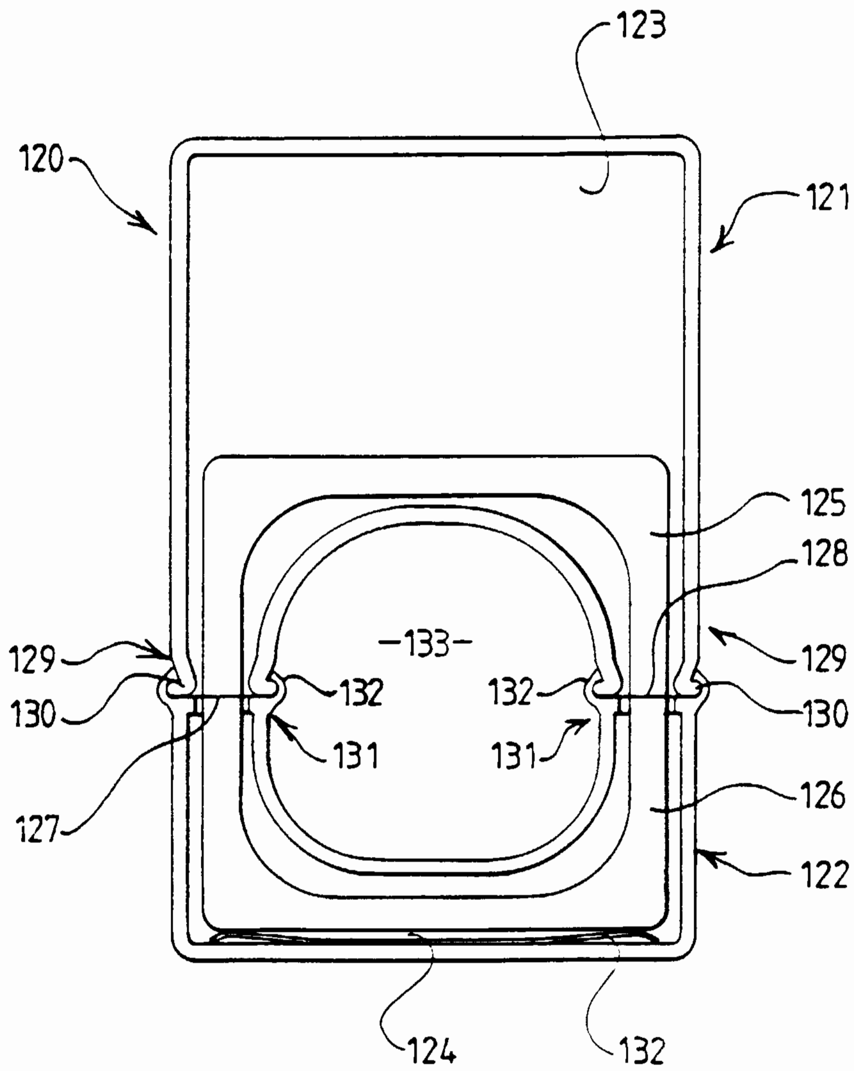

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FIG 18