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(54) **ACOUSTIC EMITTER FOR THE TREATMENT OF OIL AND GAS WELLS**

(57) An acoustic emitter for treating oil and gas wells takes the form of a cylindrical housing (1), consisting of two sealed chambers (4;10) and one chamber (2) that communicates with the environment via apertures (3). A first sealed chamber (10) is filled with air and has sealed electrical lead-ins (11), while the second sealed chamber (4) is filled with an electrically insulating liquid. A magnetostrictive transducer (7), with a cylindrical core with an electrical winding and end pieces (8) made of resilient material between them, is placed in the second chamber (4) filled with electrically insulating liquid. The technical result is an increase in the radius of effective action of the acoustic emitter on the well bottom zone, due to the increased acoustic power of the magnetostrictive transducer which has a predominantly radial direction of radiation, and also due to the prevention of corrosive destruction of the emitter.

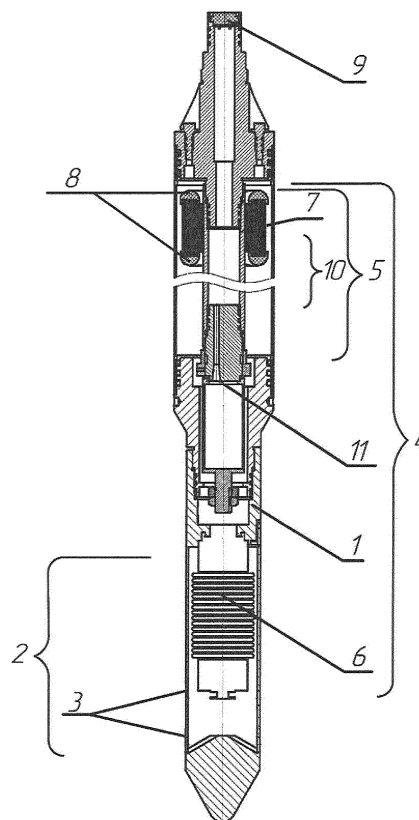


Fig. 2

Description

[0001] The invention relates to the oil and gas industry and is intended for the treatment of the well bottom zones of oil and gas wells, for the purpose of increasing their output. One method of achieving this objective is that of treating the productive layer with acoustic field energy. To create such a field, two types of emitting systems are most commonly used, namely the magnetostrictive and the piezoceramic types, the basic frequency range of which is within the range of 10-25 kHz. Each of said two types of emitter has its advantages and drawbacks, and their use depends on numerous factors.

[0002] For emitters (devices) with magnetostrictive transducers, a rod-shaped type of active element, known as a magnetostrictor, is most frequently used. The main argument in favour of selecting this rod-shaped transducer is the possibility of producing emitters with small dimensions. A liquid or a waveguide is used as the passive element for transferring the energy of the elastic oscillations generated by the active element (magnetostrictor) into the medium to be treated.

[0003] Devices for acoustic treatment of the well bottom zones of productive layers are known from the patents RU 2026970 and RU 2674165, in which magnetostrictive transducers of the rod-shaped type with electrical windings on the rods are located in an evacuated chamber. The energy of the elastic oscillations is transferred to the medium to be treated by creating an oscillatory motion of the liquid filling the chamber and therefore of the wall of the emitter housing, which acts as a resonator.

[0004] In some cases, the passive element used for transferring the energy is a waveguide or an acoustic transformer, in which case, in addition to transferring the energy, the waveguide has the function of protecting the magnetostrictor from direct contact with the corrosive downhole medium. This design is used in Patent RU 2196217.

[0005] The transfer of the magnetostrictor energy also takes place by means of a waveguide in the patent RU 2634769, but, by contrast with the previous case, the magnetostrictive rod-shaped transducer is located in a chamber of the open type, in direct contact with the downhole medium.

[0006] It should be noted that in all the aforementioned devices, rod-shaped magnetostrictive transducers are used as the acoustic radiation source. The main drawback of such devices is that the emitting surface of the device has a small area, but the magnetostrictive transducers themselves radiate much of the energy in the axial direction and only a small fraction of the energy goes in the radial direction. The task of the proposed invention is to increase the efficiency of oil recovery. The technical result is an increase in the radius of effective action of the acoustic emitter on the well bottom zone of the layer, due to the increased acoustic power of the magnetostrictive transducer which has a predominantly radial direction of radiation, and also due to the prevention of corrosive destruction of the emitter and the increase in its efficiency.

[0007] The technical result is achieved because the acoustic emitter comprises a constituent housing, consisting of two sealed chambers and one chamber that communicates with the environment via apertures formed in the lower part of the constituent housing. Sealed electrical lead-ins, for the connection of the excitation windings of the magnetostrictive transducer, are placed in the cavity of the first sealed chamber (coaxial with the geophysical head), which is filled with air. According to the invention, an acoustic magnetostrictive transducer of cylindrical shape, with an electrical winding, is placed in the second sealed chamber, which is filled with electrically insulating liquid. A characteristic of the design of the magnetostrictive transducer is that between the cylindrical core of the magnetostrictive transducer and its winding there are fitted end pieces made of resilient material, which are used for uniform packing, to provide a minimum gap between the winding and the cylindrical core itself, and for fastening the magnetostrictive transducer in the sealed chamber. The sealed chamber filled with liquid terminates in a bellows which is required for equalizing the pressure in the sealed chamber of the emitter with the external downhole pressure. The electrically insulating liquid is poured into the sealed chamber of the emitter through an opening in the end of the bellows, which is sealed with a plug.

[0008] The mechanical oscillations of the magnetostrictive transducer with the cylindrical core have a radial direction; that is to say, they are transmitted through the electrically insulating liquid to the housing of the emitter, acting as a resonator, and from there to the downhole medium in which the formation of the acoustic field in the well and the well bottom zone takes place. Individual parts in the emitter housing are made of non-magnetic materials, enabling electrical losses to be minimized.

[0009] Thus, the minimizing of electrical losses and the good heat dissipation from the magnetostrictive transducer through the electrically insulating liquid to the walls of the emitter housing, and through them into the downhole medium, provide stable thermal conditions for the device, and, together with the isolation of the magnetostrictive transducer from the corrosive downhole medium, make it possible to increase the operating reliability and efficiency of the emitter, and consequently the effectiveness of the acoustic treatment of the layer.

Calculation of the resonance frequency

[0010] Ring-shaped magnetostrictive transducers radiate sound from their inner or outer surface, depending on the

positioning of the screen. In the present case, radiation takes place into the internal medium with a uniform azimuth characteristic of directionality in a plane perpendicular to the axis of Fig. 1.

[0011] For a magnetostrictive transducer assembled from thin rings and operating with a transverse piezoelectric effect, the intrinsic frequency is determined by the equation

$$f_0 = \frac{c}{2 \pi R}, \quad (1)$$

where c is the speed of sound in the material from which the core of the ring-shaped transducer is assembled,

$$c = \sqrt{\frac{E}{\rho}}$$

E is Young's modulus, 2.18×10^{11} Pa

ρ is the density of the material; for Permendur, $\rho = 8.15 \times 10^3$ kg/m³

R is the mean radius of the ring,

$$\frac{\left[\frac{100-70}{2} + 70 \right]}{2} = 42.5 \times 10^{-3} \text{ m}$$

[0012] Let us calculate the speed of sound in Permendur:

$$c = \sqrt{\frac{E}{\rho}} = \sqrt{\frac{2.18 \times 10^{11}}{8.15 \times 10^3}} = 0.517189 \times 10^4 = 5171.89 = 5172 \text{ m/s.}$$

[0013] Then the resonance frequency of the ring-shaped magnetostrictive transducer is:

$$f_0 = \frac{5172}{2 \pi 42.5 \times 10^{-3}} = 19368 \text{ Hz, say } 19500 \text{ Hz.}$$

[0014] Thus, the intrinsic frequency of the downhole acoustic emitter will be:

$f_0 = 19500$ Hz.

[0015] Other electrical parameters were calculated by the methods set out in [1], [2] and [3]:

[1] I.P. Golyamina, "Ul'trazvukovye preobrazovateli", Moscow, 1972, 200 pp;

[2] A.V. Donskoy and O.K. Keller, "Ul'trazvukovye elektrotekhnologicheskie ustanovki", Leningrad, Energoizdat, 1982, 208 pp.;

[3] GOST 27955-88 (IEC 782-84) Preobrazovateli ul'trazvukovye magnitostriksionnye. Metody izmereniya kharakteristik.

Fig. 1 shows the direction of the oscillations of the cylindrical (ring-shaped) magnetostrictive transducer, where R is the external radius of the core, and a is the width of the ring;

Fig. 2 shows a longitudinal section through the downhole acoustic emitter.

[0016] The acoustic emitter for treating oil and gas wells comprises a constituent housing 1, consisting of a plurality of chambers, namely two sealed chambers 4 and 10 and one (lower) chamber 2 that communicates with the environment via apertures 3 formed in the lower part of the acoustic emitter housing. Sealed electrical lead-ins 11 are brought into the cavity of the sealed chamber 10 (coaxial with the geophysical head 9), which is filled with air, for the connection of the excitation windings of the magnetostrictive transducer 7.

[0017] According to the invention, in the sealed chamber 4, filled with electrically insulating liquid, in the vibration zone 5, there is placed a magnetostrictive transducer 7 with a core of cylindrical shape with an electrical winding, while, between the cylindrical core of the transducer and its winding there are fitted end pieces 8 made of resilient material, which are used for uniform packing, for providing a minimum gap between the winding and the cylindrical core, and for fastening the magnetostrictive transducer 7 in the sealed chamber.

[0018] The components of the acoustic emitter housing 1 are sealed with rubber packing rings (not shown in the figure), and the parts are secured mechanically with detachable rubber connectors (not shown in the figure).

[0019] A standard geophysical head 9 is fitted at the upper end of the emitter housing 1 above the sealed chamber 4 with the magnetostrictive transducer 7, for connecting the downhole acoustic emitter to a supply cable (not shown in the figure), the head being connected to the electrical windings of the magnetostrictive transducer 7, using sealed electrical lead-ins 11. The chamber 2, communicating with the downhole medium through an aperture 3, takes the form of a cylinder terminating in a conical part. The pressure in the inner sealed chamber 4 of the emitter, filled with electrically insulating liquid, is equalized with the downhole pressure by means of a bellows 6.

[0020] The device operates in the following manner. An alternating voltage at an operating frequency corresponding to the resonance frequency of the magnetostrictive transducer 7 is supplied from a surface generator by means of a cable through a standard geophysical head 9 and sealed electrical lead-ins 11 to the electrical winding of the ring-shaped magnetostrictive transducer 7 located in the sealed chamber 4. The contacts of the geophysical head 9 are connected to the sealed electrical lead-ins 11 by means of conductors (not shown in the figures) passing through the cavity of the sealed chamber 10. At the same time, a magnetic biasing current is supplied from the same generator to the same electrical winding.

The alternating current flowing through the core winding of the ring-shaped magnetostrictive transducer 7 creates an alternating electromagnetic field in the core, causing a change in the dimensions of the core in the form of radial oscillations. These oscillations, perpendicular to the cylindrical surface of the core, in the form of compression and expansion waves, are transmitted to the liquid surrounding the core, which in turn causes oscillations in the walls of the emitter housing 1 (in the vibration zone 5) and in the surrounding medium. Between the cylindrical core and the winding of the magnetostrictive transducer 7 there are fitted end pieces 8 made of resilient material, which are used for uniform packing of the electrical winding, for providing a minimum gap between the winding and the cylindrical core, for protecting the winding conductor from wear, and for fastening the magnetostrictive transducer 7.

[0021] Additionally, the electromagnetic field of the electrical winding of the ring-shaped magnetostrictive transducer 7 generates eddy currents in the walls of the emitter housing 1 in the vibration zone 5, the walls heating up in these conditions. The downhole medium, coming into contact with the metal housing 1 of the emitter in the vibration zone 5, heats up as a result of thermal conductivity. Thus, during the operation of the downhole acoustic emitter, a simultaneous wave and local heating action takes place on the downhole medium with sufficient power, which is particularly important for operation in wells with high-viscosity oil. The equalization of the pressure of the sealed chamber 4, filled with electrically insulating liquid, with the external downhole pressure takes place because of the bellows 6 which is positioned in the chamber 2 and communicates with the downhole medium through the apertures 3.

[0022] By using the aforesaid device at low energy cost it is possible to carry out effective thermo-acoustic treatment of the well bottom zone with the aim of increasing its production rate by cleaning the perforations of the downhole equipment and the pores of the collector to remove mechanical contaminants and gas hydrate and heavy oil deposits. The invention makes it possible to increase the efficiency of oil recovery, especially in the extraction of high-viscosity oil.

Claims

1. Acoustic emitter for treating oil and gas wells, taking the form of a cylindrical housing (1), consisting of two sealed chambers (4;10) and one chamber (2) that communicates with the environment via apertures (3), one first sealed chamber (10) being filled with air and having sealed electrical lead-ins (11), while the second sealed chamber (4) is filled with an electrically insulating liquid, **characterized in that** a magnetostrictive transducer (7), with a cylindrical core with an electrical winding and end pieces (8) made of resilient material between the cylindrical core and the electrical winding, is placed in the second sealed chamber (4) filled with electrically insulating liquid.
2. Acoustic emitter for treating oil and gas wells according to Claim 1, **characterized in that** the magnetostrictive transducer (7) comprises a core of cylindrical shape, the radial radiation of which causes an increase in the acoustic power of the radiation and effective treatment of the downhole medium in the well bottom zone.
3. Acoustic emitter for treating oil and gas wells according to one of Claims 1 or 2, **characterized in that** the one chamber (2) that communicates with the environment via apertures (3) is a lower chamber and the apertures (3) are formed in the lower part of the housing (1).

4. Acoustic emitter for treating oil and gas wells according to one of Claims 1 to 3, **characterized in that** the one chamber (2), that communicates with the environment via apertures (3), takes the form of a cylinder terminating in a conical part.
5. Acoustic emitter for treating oil and gas wells according to one of Claims 1 to 4, **characterized in that** the second sealed chamber (4) filled with the electrically insulating liquid terminates in a bellows (6) which is used for equalizing the pressure in the sealed chamber (4) of the emitter with the external downhole pressure.
6. Acoustic emitter for treating oil and gas wells according to Claim 5, **characterized in that** electrically insulating liquid is poured into the second sealed chamber (4) of the emitter through an opening in the end of the bellows (6), which is sealed with a plug.
7. Acoustic emitter for treating oil and gas wells according to Claim 5 or 6, **characterized in that** the bellows (6) is positioned in the one chamber (2), that communicates with the environment via apertures (3).
8. Acoustic emitter for treating oil and gas wells according to one of Claims 1 to 7, **characterized in that** a geophysical head (9) is fitted at the upper end of the housing (1) above the second sealed chamber (4) with the magnetostrictive transducer (7), the geophysical head (9) being connected to the electrical winding of the magnetostrictive transducer (7), using said electrical lead-ins (11).
9. Acoustic emitter for treating oil and gas wells according to one of Claims 1 to 8, **characterized in that** the first sealed chamber (10), that is filled with air, is coaxially surrounded by the second sealed chamber (4) filled with the electrically insulating liquid.
10. Acoustic emitter for treating oil and gas wells according to one of Claims 1 to 9, **characterized in that** the magnetostrictive transducer (7) is ring-shaped.

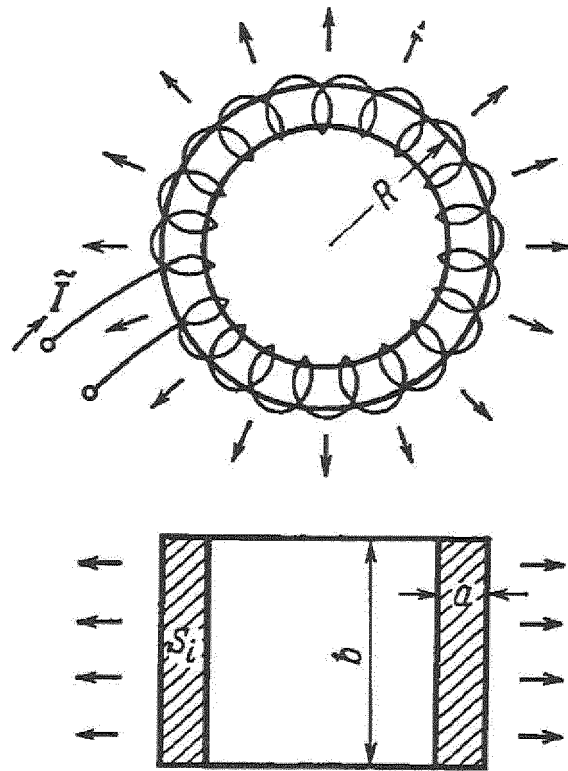


Fig. 1

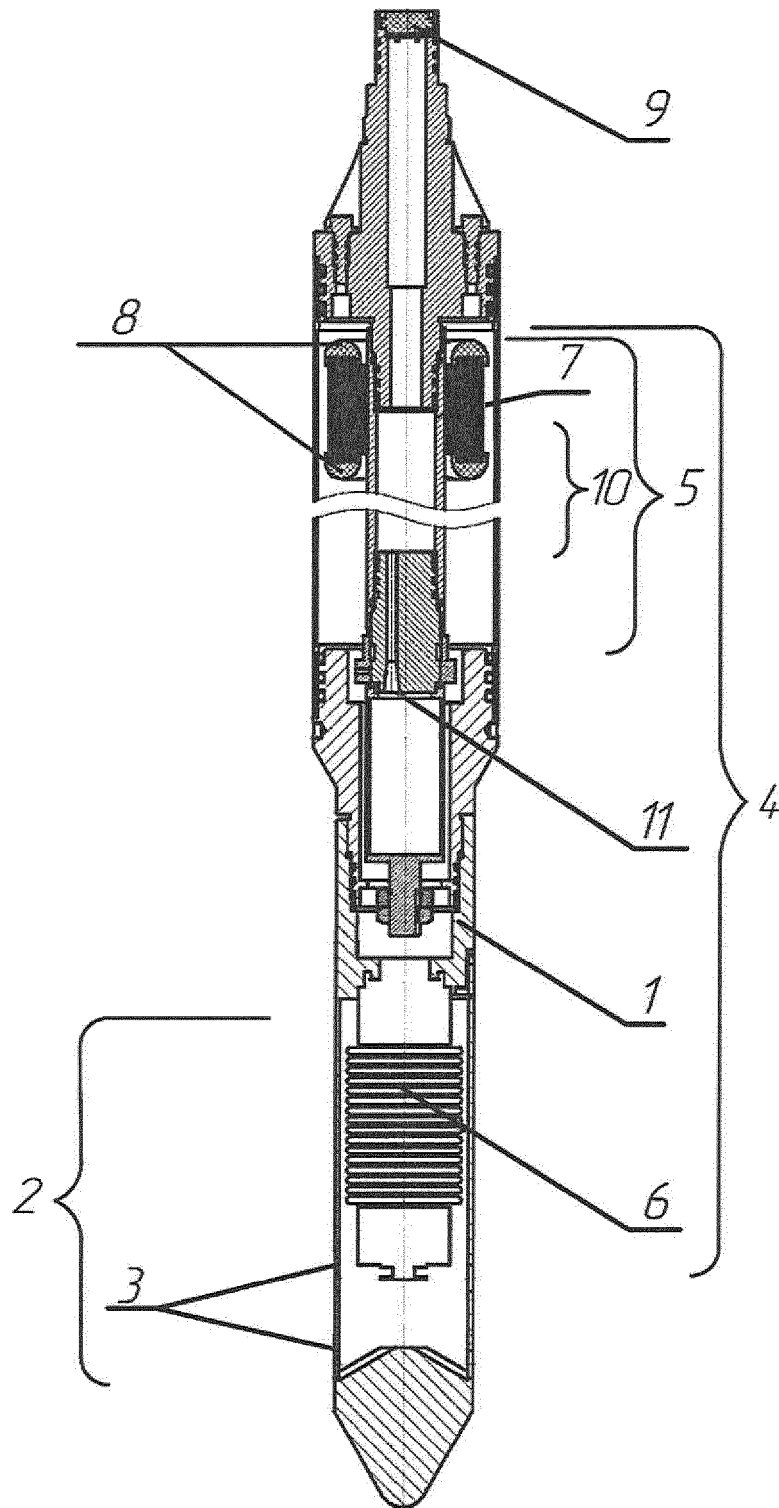


Fig. 2



EUROPEAN SEARCH REPORT

Application Number
EP 20 18 9344

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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 14 January 2021	Examiner Jucker, Chava
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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14-01-2021

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US 2879496	A	24-03-1959	NONE
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RU 2196217	C2	10-01-2003	NONE

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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