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TOPIC: THREE-PHASE ELECTRIC ENERGY CONVERTER FOR EXCITATION OF LOW-FREQUENCY MECHANICAL VIBRATIONS

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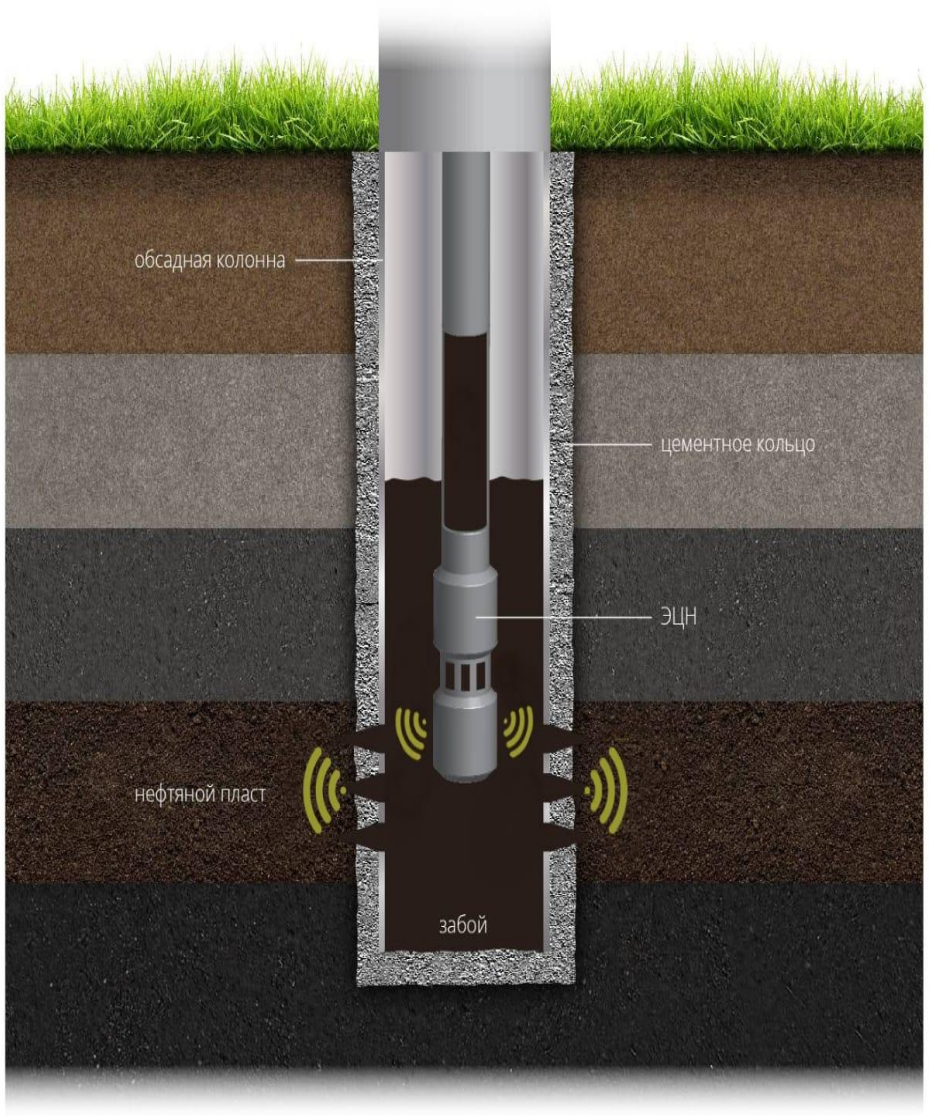
A method has been developed to reduce the abnormal viscosity of reservoir oil by periodically using the method of physical impact on the product reservoir, which provides an increase in the reservoir coverage factor by flooding and stimulating the process of transition of surfactants from the injected solution into oil.

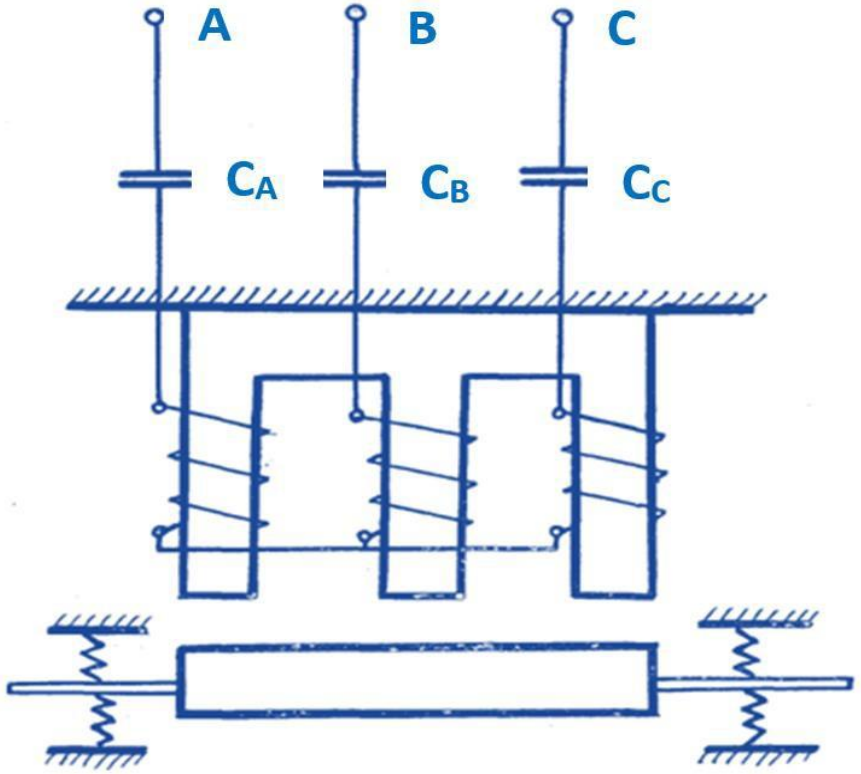
The solutions obtained are new to petroleum science and are of considerable interest. The research results can be recommended for widespread use in oil fields, at various stages of development with different types of reservoir rocks. Their implementation will improve technical and economic indicators

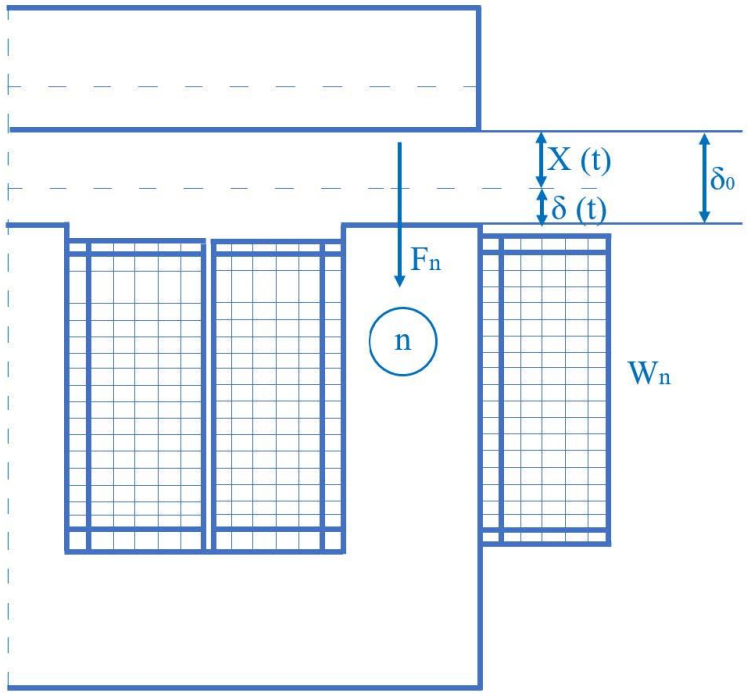
Well section with submersible equipment



Three-phase electromagnetic exciter of low-frequency mechanical vibrations

patents SU 1356136 A1 and SU 13561137 A1





Equations of the electrical and mechanical parts of the electromagnetic exciter of mechanical vibrations

$$ir + W\frac{d\Phi}{dt} + \frac{1}{c}\int idt = U \qquad (1)$$

$$m\frac{d^2x}{dt^2} + r_{mex}\frac{dx}{dt} + \frac{1}{\lambda}x = h\Phi_{\Sigma}^2 \qquad (2)$$

$$\mathrm{U} = 4{,}44 \cdot W \cdot f_{(k)} \cdot \Phi_{\Sigma} \qquad (3)$$

$$F = \frac{1}{2\mu_0 S_{\mu}}\Phi_{\Sigma}^2 = h\Phi_{\Sigma}^2 \qquad (4)$$

$$\omega_{(k)} - \omega_{(k-1)} = \nu \qquad (5)$$

$$\Phi_{\underset{m}{\Sigma}} = \Phi_{\underset{m}{(k)}} - \Phi_{\underset{m}{(k-1)}} \qquad (6)$$

$$x(t) = x_m \cdot sin(\nu t + \theta) \qquad (7)$$

$$U_A = i_A r_A + \frac{1}{C_A}\int i_A dt + W_A\frac{d}{dt}(\Phi_A)$$

$$U_B = i_B r_B + \frac{1}{C_B}\int i_B dt + W_B\frac{d}{dt}(\Phi_B) \qquad (8)$$

$$U_C = i_C r_C + \frac{1}{C_C}\int i_C dt + W_C\frac{d}{dt}(\Phi_C)$$

Here: $\boldsymbol{U_{A_{(B.C)}}}$ - corresponding phase voltages A, B и C;

$\boldsymbol{r_A = r_B = r_C = r}$ – active resistances of coils located in phases A, B и C;

$\mathrm{C_A = C_B = C_C = C}$ – capacitors located in phases A, B и C;

$\boldsymbol{W_A = W_B = W_C = W}$ – the number of turns corresponding to coils in phases A, B и C;

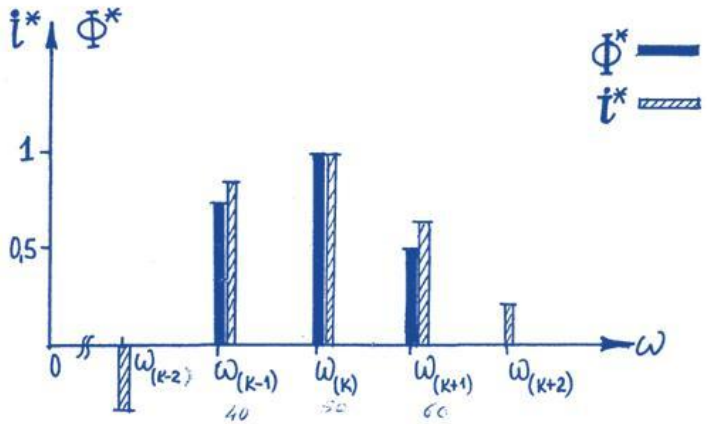
$\Phi_{A_{(B.C)}}$-magnetic fluxes corresponding to magnetic branches in phases A, B и C;

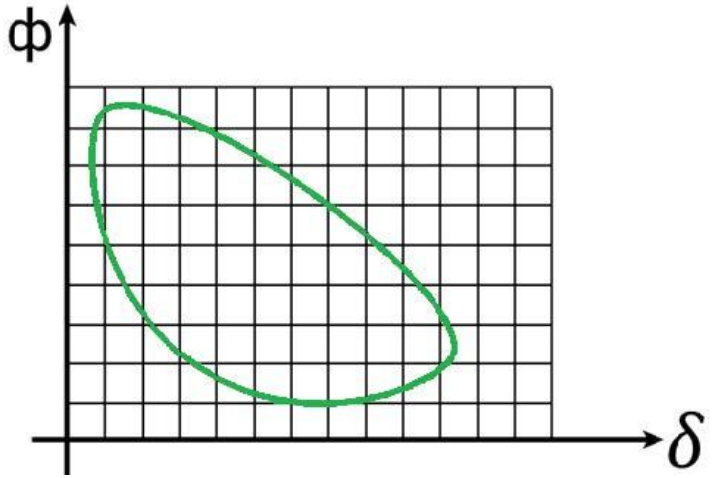
Here: **m**-generalized mass;

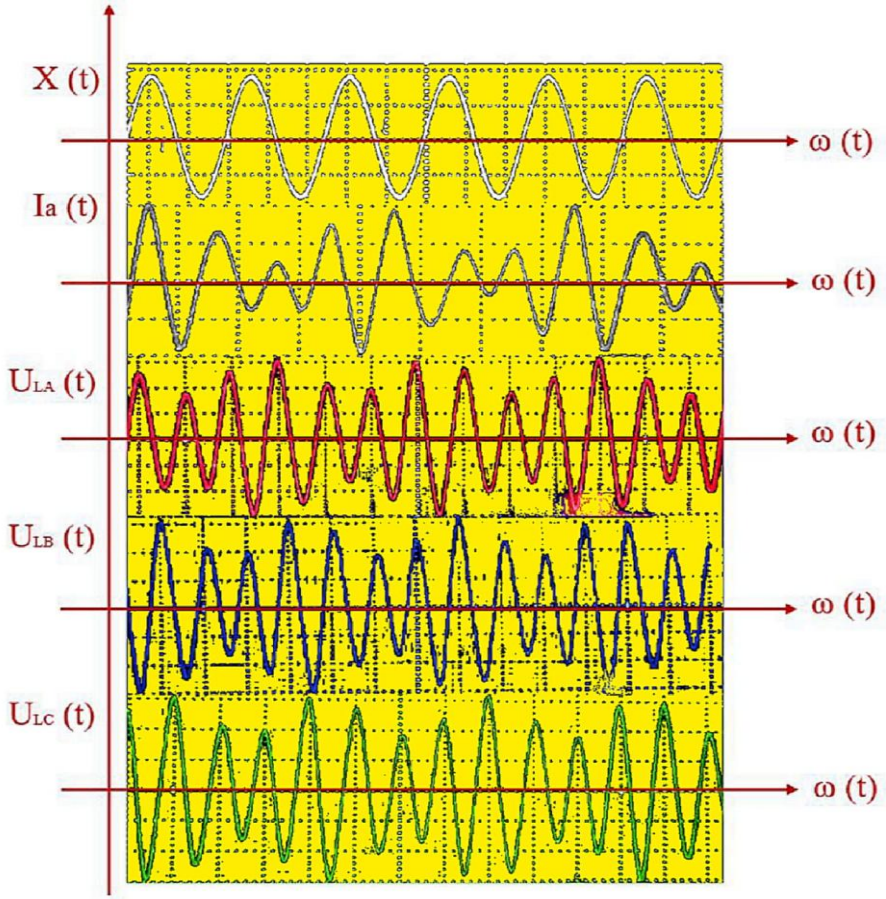
$\boldsymbol{r_{mex} -}$ friction resistance ;

$\boldsymbol{\frac{1}{\lambda}}$ – spring stiffness; $\boldsymbol{x}$ – mechanical movement of the device

Parameters of the electromagnetic exciter showing the wave processes stimulated in the formation







Traction force of the vibration exciter of mechanical vibrations

$$\boldsymbol{F_{\Sigma} = F_{\Sigma}(t) = h\left[\Phi^2_{\Sigma_A}(t) + \Phi^2_{\Sigma_B}(t) + \Phi^2_{\Sigma_C}(t)\right]} \qquad \textbf{(9)}$$

$$\frac{1}{h}F_{\Sigma}(t) = \left[\begin{matrix}\Phi_{(к-1)_m}\cdot sin\left(\omega_{(k-1)}\cdot t + \alpha_{(k-1)}\right) + \Phi_{(к)_m}\cdot sin\left(\omega_{(k)}\cdot t + \alpha_{(k)}\right) + \\ + \Phi_{(к+1)_m}\cdot sin\left(\omega_{(k+1)}\cdot t + \alpha_{(k+1)}\right)\end{matrix}\right]^2$$

$$+\left[\begin{matrix}\Phi_{(к-1)_m}\cdot sin\left(\omega_{(k-1)}\cdot t + \alpha_{(k-1)} - 120^0\right) + \Phi_{(к)_m}\cdot sin\left(\omega_{(k)}\cdot t + \alpha_{(k)} - 120^0\right) \\ + \Phi_{(к+1)_m}\cdot sin\left(\omega_{(k+1)}\cdot t + \alpha_{(k+1)} - 120^0\right)\end{matrix}\right]^2$$

$$+\left[\begin{matrix}\Phi_{(к-1)_m}\cdot sin\left(\omega_{(k-1)}\cdot t + \alpha_{(k-1)} - 240^0\right) + \Phi_{(к)_m}\cdot sin\left(\omega_{(k)}\cdot t + \alpha_{(k)}\right) - 240^0 \\ + \Phi_{(к+1)_m}\cdot sin\left(\omega_{(k+1)}\cdot t + \alpha_{(k+1)} - 240^0\right)\end{matrix}\right]^2 \textbf{(10)}$$

Technical specifications

1

2

- The depth of the wells being processed —up to 5 km ;
- Operating temperature -up to 100ºC;
- Energy consumption -1.5 kJ;
- The outer diameter — 102 mm;
- The length of the device — 2700 mm;
- Supply voltage 220 V / 50 Hz;
- Power supply - 500W

Scope of application

Solutions using the technology of physical impact on the reservoir

Increasing the production rate of producing wells

- high efficiency on a low-yield well stock
- rehabilitation of wells after reducing the effect of hydraulic fracturing
- efficiency at any water level

Increasing the recoverability of hydrocarbons at the development site

- Seismoacoustic tomography of the interwell space
- the inclusion of unwashed whole hydrocarbons in the work
- withdrawal of wells from inactivity and conservation
- increasing the KIN for the development object

The challenge of fluid inflow at the stage of development

- there is no risk of disruption of the geological structure of the reservoir
- efficiency in a short time
- selective exposure

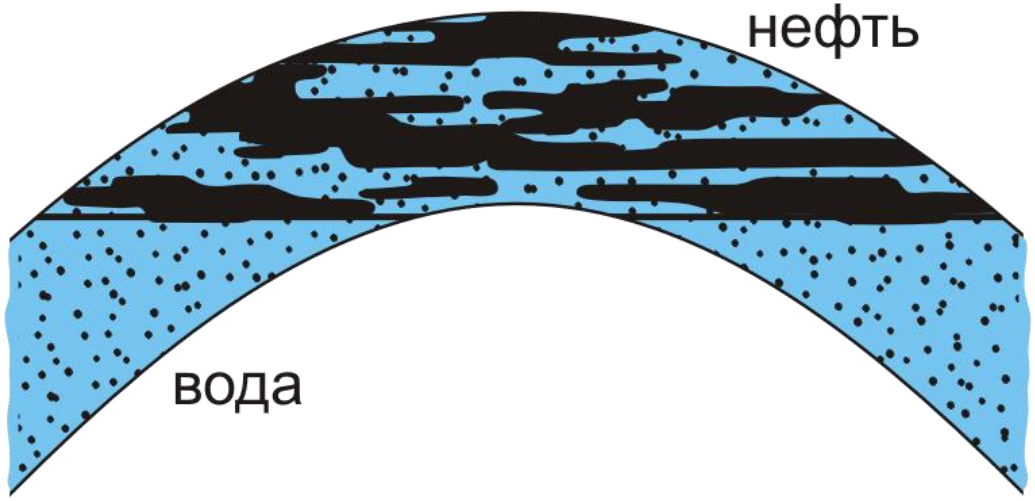
Increasing the pick-up rate of injection wells

- selective redistribution of the intake capacity of injection wells
- improving the efficiency of flooding
- the inclusion of poorly drained interlayers in the work
- of well rehabilitation after reducing the effect of hydraulic fracturing

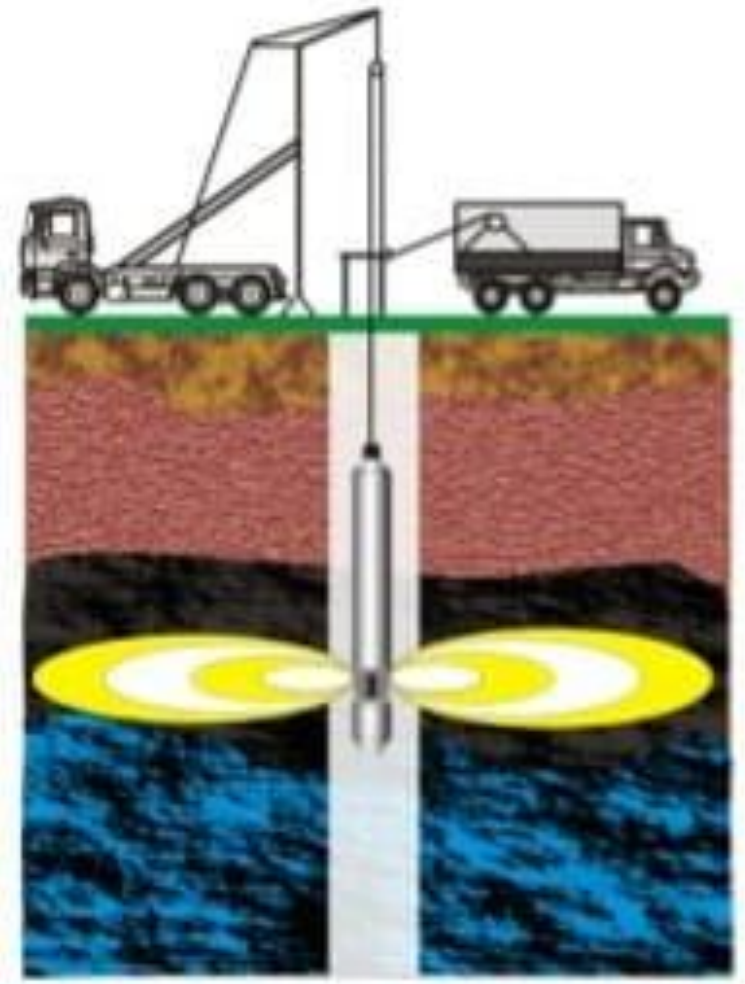
Reduction of the cost of the extracted product

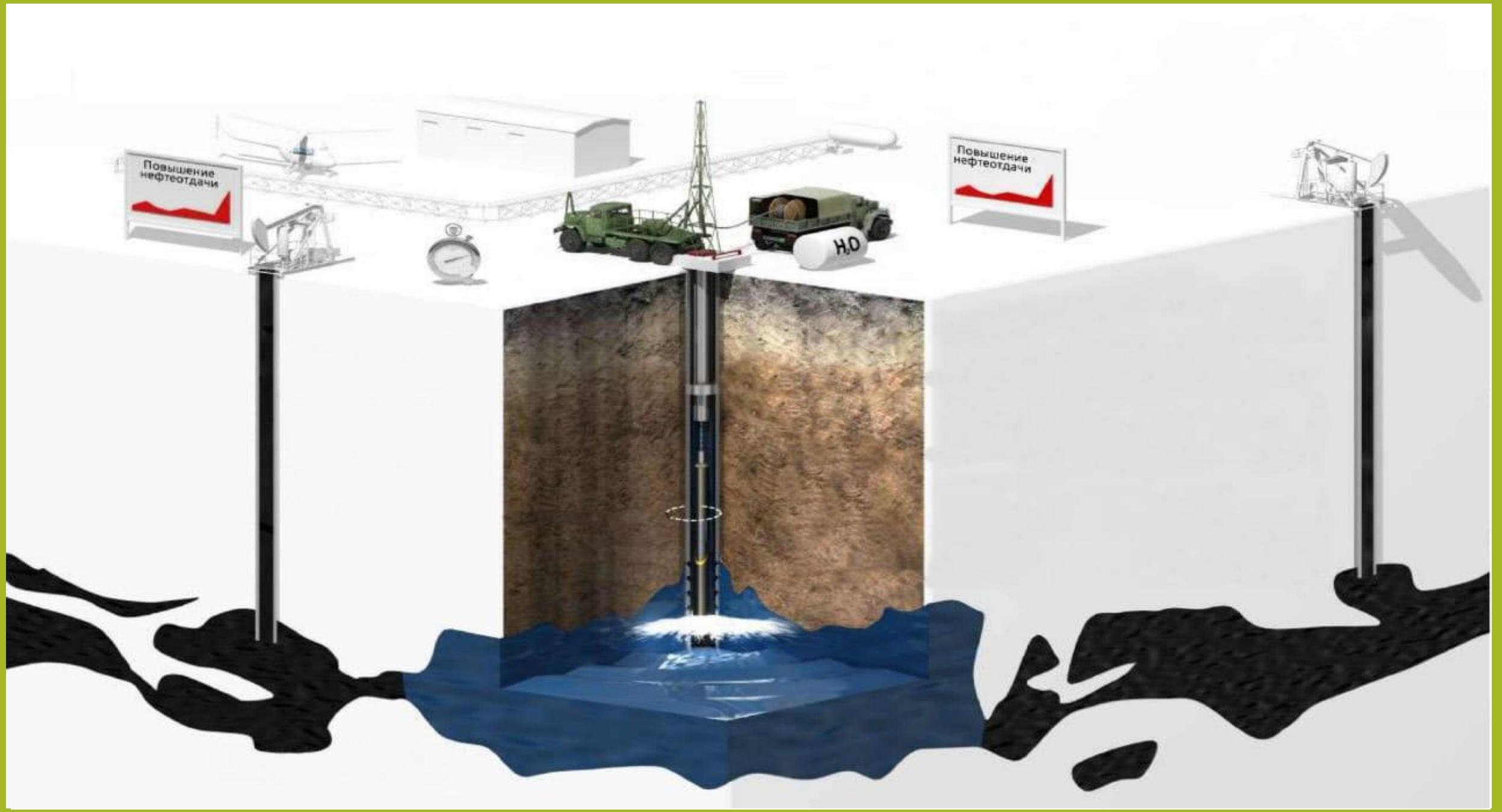
Reservoir elasticity

The oil deposit in the reservoir is layered, is in an elastic state and, when physically exposed to it, represents a set of oscillatory systems, where each layer, if it is a resonator, has its own frequency.



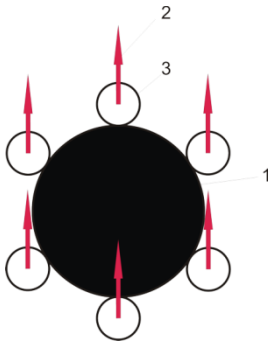
Technological scheme of work




Повышение нефтеотдачи
Повышение нефтеотдачи
H2O

Nonlinearity and resonance

- **Modeling of the process of the physical method of exposure in the product layer**



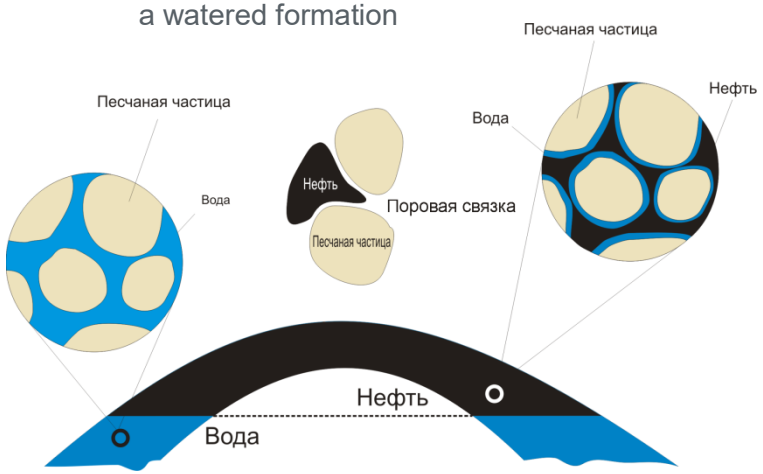
1 drop of oil;

2-gravitational forces;

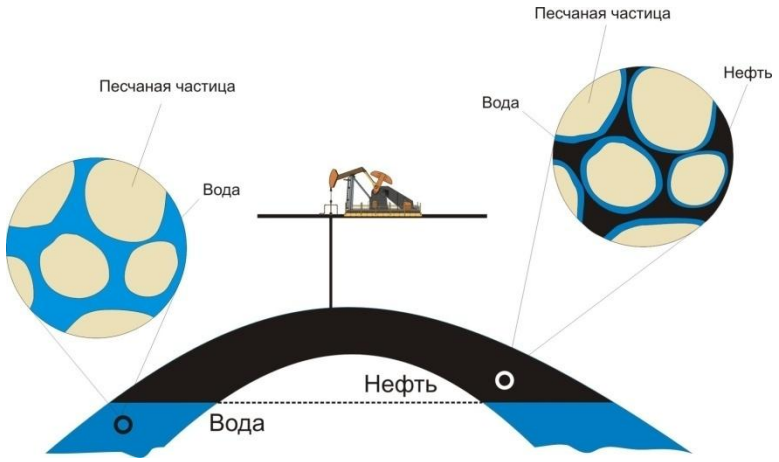
3-gas bubbles.

Scheme of flotation of an oil drop in a watered formation

Increasing the speed and completeness of oil displacement by water



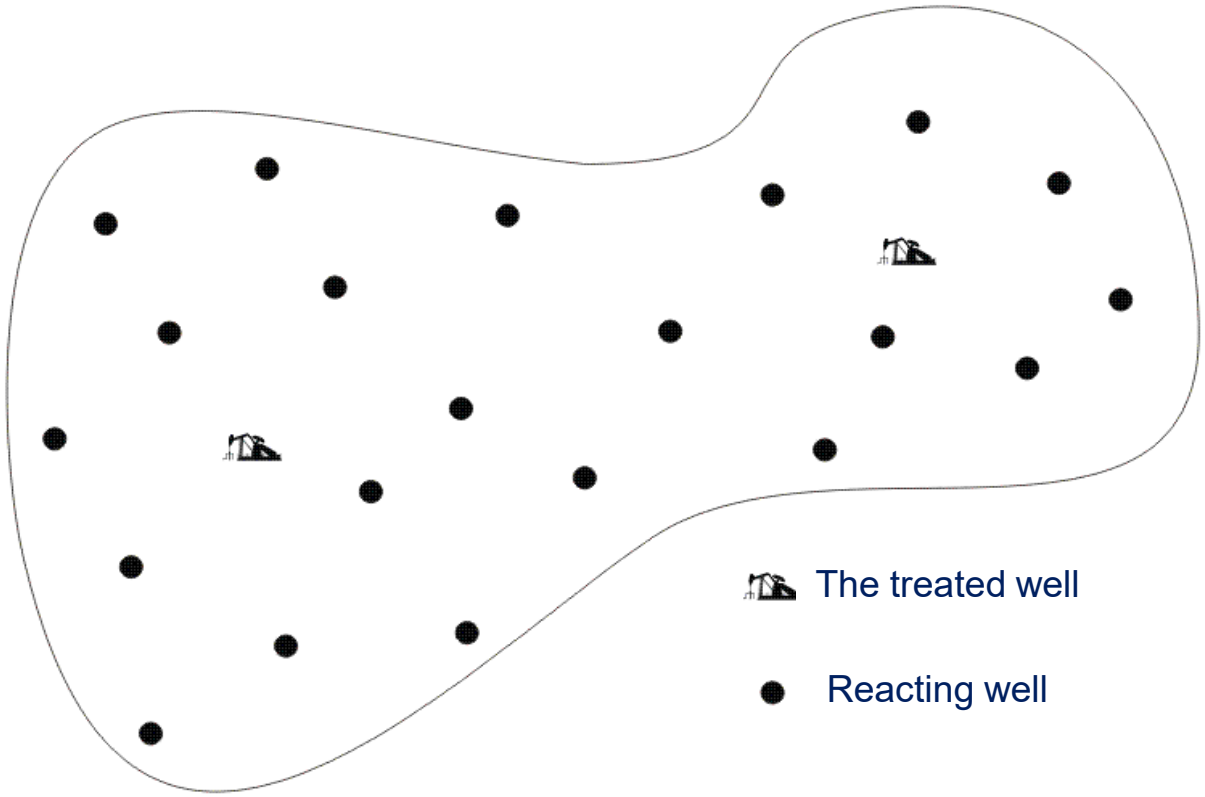
Changes in the stress state of rocks and the structure of pore space



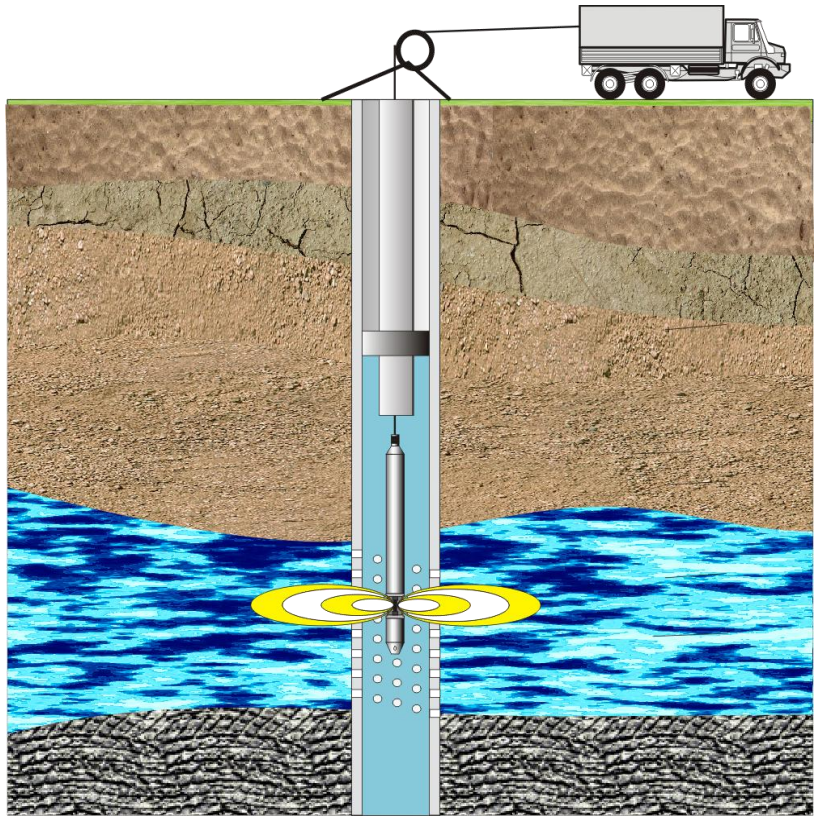
The increase in relative phase permeability for oil is greater than for water

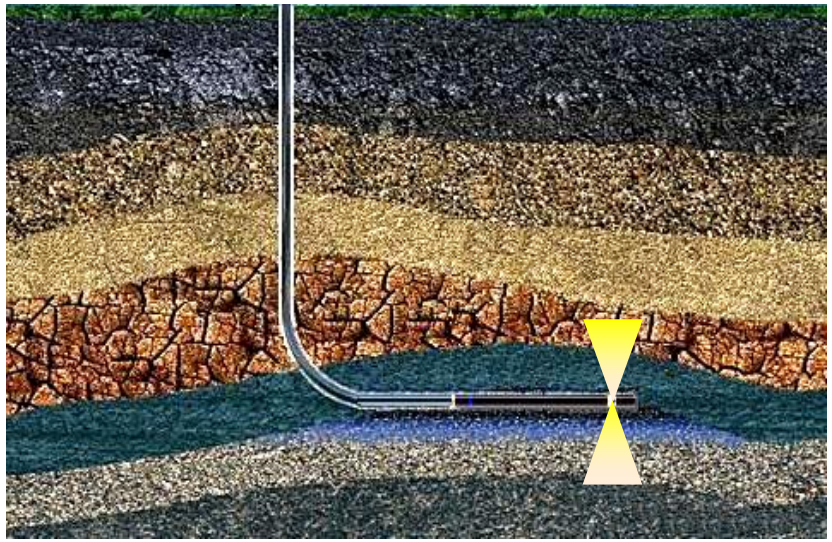
The effectiveness of the impact

Elastic wave propagation



Promising areas





Thank you for your attention