

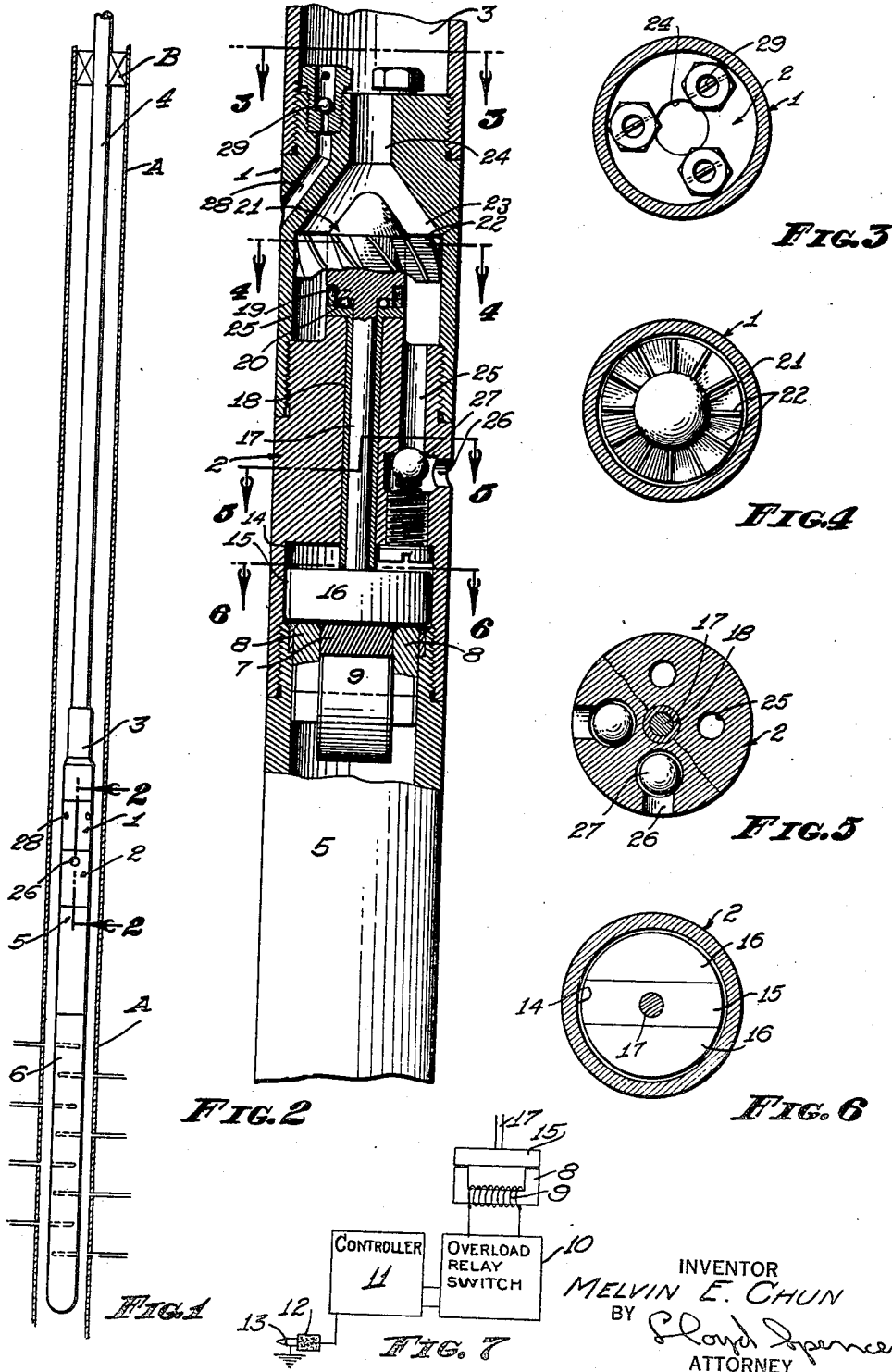
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ELECTRICAL GENERATOR FOR GUN PERFORATORS

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ELECTRICAL GENERATOR FOR GUN PERFORATORS

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My invention relates to electrical generators for gun perforators and among the objects of my invention are:

First, to provide an electrical generator which is adapted to be mounted in proximity to a gun perforator for the purpose of supplying electrical energy thereto and thereby controlling the discharge of the gun perforator;

Second, to provide an electrical generator of this type which is particularly adapted to be mounted between a gun perforator and a tubing string and is designed to operate in response to fluid flow through the tubing string;

Third, to provide an electrical generator of this type which lends itself to well completion programs wherein, by reason of extremely high formation pressures, it is undesirable to open the producing zone to the interior of the well casing by means of a conventional gun suspended on an electrical cable, for the reason that in removing the gun under such conditions there is danger of the well "blowing out," said generator minimizing this danger by reason of the fact that it enables the gun to be suspended from the tubing which may remain in the well and through which the oil from the zone perforated may be conducted, at least during its initial high pressure period;

Fourth, to provide an electrical generator for gun perforators which may be caused to operate periodically by controlling the flow of fluid through the tubing string, so that periodic current impulses may be supplied to the gun for firing one shot at a time;

Fifth, to provide an electrical generator for gun perforators which is inherently safe in that it permits the use of a gun equipped with electrical rather than percussive ignition means and the generator is not capable of generating electricity until fluid is pumped into the tubing; and

Sixth, to provide an electrical generator for gun perforators which is particularly rugged, yet simple of construction and capable of being left for comparatively long periods of time in a well.

With the above and other objects in view, as may appear hereinafter, reference is directed to the drawing in which:

Figure 1 is an elevational view of a gun perforator and section of well tubing incorporating my electrical generator;

Figure 2 is an enlarged fragmentary sectional view thereof taken through 2—2 of Figure 1;

Figures 3, 4, 5 and 6 are transverse sectional views taken substantially through 3—3, 4—4, 5—5 and 6—6, respectively, of Figure 2; and

Figure 7 is a wiring diagram illustrating the manner in which the generator is electrically connected to the parts of the gun perforator.

The generator is contained in upper and lower

housings 1 and 2, which are cylindrical in form and screw-threaded together. The upper housing 1 is connected through a coupling 3 to a tubing string 4. The lower housing is connected to a controller shell 5 which in turn is connected to a gun perforator 6. The gun perforator and controller may be conventional and may be constructed in the manner disclosed in the Johnston patent for Casing perforator gun, No. 2,048,451.

The upper end of the controller shell 5, which is screw-threaded to the lower housing 2, is provided with an end plate 7 which may be welded or otherwise secured in place to form a fluid-tight closure. Sealed in the end plate 7 are a pair of pole pieces 8 which extend into the controller shell 5 and suitably support a generator coil 9. The generator coil is connected preferably through an overload relay 10 to a controller 11 in the form of a multiple contact step-by-step switch such as that disclosed in the above-mentioned patent. Each of the contacts of the controller is connected to a cartridge 12 containing an electrically responsive fuse wire. The cartridge, upon firing, discharges a bullet 13 from the gun.

However, in those instances where a comparatively few shots are to be fired the controller may be dispensed with and the relay connected directly with the several cartridges, so that when the electrical energy generated exceeds a predetermined amount the relay fires the bullets simultaneously.

The lower housing 2 is provided at its lower end, above the controller shell, with a chamber 14 in which is mounted an armature 15. The armature is in the form of a bar of highly magnetic material, such as the material known commercially as "Alnico." The bar extends diametrically with respect to the axis of the housing so that upon rotation its ends pass over the pole pieces 8. Inasmuch as the chamber may be filled with liquid or lubricant for the purpose of excluding well liquid, it is preferred to mount non-magnetic complementary segments 16 on either side of the armature bar.

The armature is provided with a stem 17 which extends upwardly through a bore centrally located in the lower housing 2. The bore may be provided with a suitable bushing 18. Above the bushing 18 the stem may be enlarged to form a head 19 which rests on a suitable bearing 20, so that the stem and armature are suspended. Secured to or integrally formed with the head 19 is a turbine wheel which may be of rudimentary form. The turbine wheel is provided with a plurality of helically mounted veins 22 so positioned that upon downward flow of fluid the veins cause rotation of the turbine.

The upper housing 1 is provided, above the lower housing 2, with a cavity 23 to accommodate

the turbine. The cavity converges upwardly in spaced relation to the turbine and communicates with a central bore 24 which communicates with the interior of the tubing string. Below the turbine wheel the lower housing is provided with vertical passages 25, each having lateral outlet ports 26. The vertical passages 25 are controlled by backflow check valves 27 which permit outward flow of fluid downwardly from the turbine, but prevent back flow of fluid upwardly into the tubing string.

The upper housing 1 is provided with a plurality of intake ports 28, each of which may be provided with intake check valves 29. The intake check valves 29 permit flow of well fluid into the tubing string at points above the turbine so that such inflow of fluid has no effect on the turbine.

Operation of my electrical generator for gun perforators is as follows: The gun perforator is loaded and the gun and turbine are assembled on the tubing string and lowered thereby into a well bore. By reason of the provision of the overload relay 10 it is possible to circulate downwardly through the tubing for the purpose of washing mud from the well before firing the gun, or such operation may be carried out before lowering the gun into position.

If circulation is desired after lowering the gun into position but before discharging the gun, the velocity of the circulating fluid may be maintained low enough that the over-load relay does not trip and complete the circuit to the controller or to the cartridges.

When it is desired to fire the cartridges the velocity of the fluid is increased, causing the generator to turn faster, increasing the voltage or current, or both, until the over-load relay causes a circuit to be completed to the controller or directly to the cartridges. If the controller is used, the velocity of the fluid is increased and decreased alternately, causing the circuit through the over-load relay and the controller to make and break. The controller itself thus operates just as if an electric circuit extended to the surface and an operator opened and closed the circuit manually such as disclosed in Patent No. 2,048,451, Johnston.

A method which may be used in conjunction with, or as an alternative to washing the well, consists in the provision of a packer B mounted on the tubing string at some point above the perforator. Before the packer is set fluid is pumped downwardly through the tubing string with sufficient velocity to cause the generator to produce electrical energy sufficient to operate the overload relay and thereby operate the controller and fire the bullet, or to fire the bullet directly, as the case may be. Thereupon the packer B may or may not be set, depending upon the well conditions. If a packer is not used, of course, a casing head seals off the area between the tubing and the casing A at the well mouth. Upon perforation the incoming fluid enters the tubing string through the intake ports 28 and the intake check valves may be so arranged as to serve as bottom hole chokes or flow beans. The gun and electrical generator are left in the well until such time as it is convenient to remove the tubing string.

Various changes and alternate arrangements may be made within the scope of the appended claims, in which it is my intention to claim all

novelty inherent in the invention as broadly as the prior arts permits.

I claim:

1. The combination in a unitary carrier with an electrically responsive well tool of a device for generating electrical energy, comprising: an electrical generator unit having a rotor and a stator; and a hydraulic drive unit for said rotor.
2. The combination with an electrically responsive well tool of a device for generating electrical energy, comprising: an electrical generator unit adapted to be lowered within a wellbore and including a rotor and a stator; a hydraulic drive unit for said rotor; and means for causing circulation of fluid around said drive unit.
3. The combination with an electrically responsive well tool of a device for generating electrical energy, comprising: a generator unit including a hydrostatically sealed stator and a permanently magnetized bar rotor exposed to well fluid pressures; and a hydraulic drive unit connected with said rotor and adapted to rotate said rotor upon flow of fluid past said drive unit.
4. The combination with an electrically responsive well tool and a tubing string, of an electrical generator interposed between said tubing string and well tool comprising: a hydraulic drive means responsive to flow of fluid through said tubing; a generator rotor connected with said hydraulic drive; and a generator stator electrically connected with said well tool and magnetically associated with said rotor.
5. The combination with an electrically responsive well tool and a tubing string, of an electrical generator interposed between said tubing string and well tool comprising: a hydraulic drive means; a housing therefor defining passages from the interior of said tubing to the exterior thereof for conducting a driving fluid around said drive means; a generator rotor connected with said hydraulic drive; and a generator stator electrically connected with said well tool and associated with said rotor.
6. A construction, as recited in claim 5, which includes further: check valves in said passages to prevent backflow of fluid therethrough into said tubing; said housing having other passages bypassing said drive means; and check valves therein permitting intake but preventing discharge from said tubing through said bypassing passages.
7. The combination with an electrically responsive well tool and a tubing string, of an electrical generator interposed between said tubing string and well tool comprising: a hydraulic drive means; a housing structure attached to said tubing string and defining a chamber for said drive means, a discharge passage from said tubing string communicating therewith and an intake passage bypassing said drive means; check valves controlling flow in said passages; a rotor driven by said drive means; and a stator electrically associated with said well tool and well.
8. The combination with an electrically responsive well tool of a device for generating electrical energy, comprising: a rotor formed of a permanent magnet; a stator including a stator coil hydrostatically sealed from said rotor and pole pieces in proximity to said rotor; and means for rotating said rotor.

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