

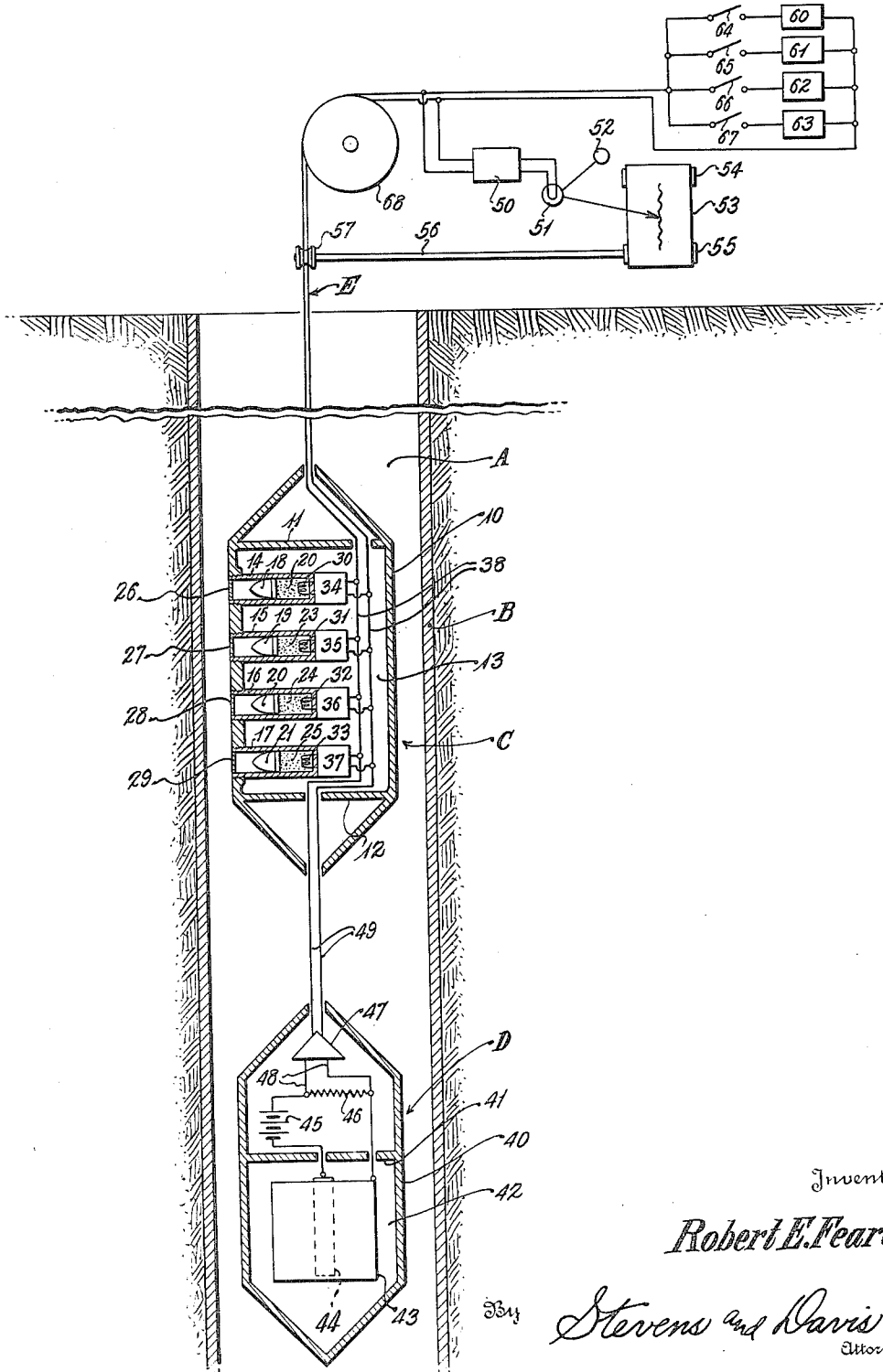
Feb. 2, 1943.

R. E. FEARON

2,309,835

WELL LOGGING APPARATUS AND METHOD THEREOF

Filed Feb. 14, 1941



Inventor

Robert E. Fearon

By

Stevens and Davis

Attorneys

UNITED STATES PATENT OFFICE

2,309,835

WELL LOGGING APPARATUS AND METHOD THEREOF

Robert Earl Fearon, Tulsa, Okla., assignor to Well Surveys, Incorporated, Tulsa, Okla., a corporation of Delaware

Application February 14, 1941, Serial No. 378,993

11 Claims. (Cl. 250—83.6)

This invention relates generally to improvements in methods of geophysical prospecting and more particularly is concerned with a method of prospecting suitable for locating and utilizing petroleum bearing strata in the vicinity of a cased well bore.

When drilling wells in petroleum fields it is usual to continue the drilling operations until a subterranean stratum of the desired richness is reached, the conclusion of drilling being determined either by use of a geophysical exploration device indicating the presence in quantity of a petroleum bed or by flow of petroleum from the well. The well bore usually is cased with a metallic sheath, progressively as the drilling proceeds or, in some instances, when drilling is concluded. After the casing of the well is completed, it is then ready for active production and collection of the deposits can be begun.

Although the foregoing practice in general constitutes a method which experience indicates will permit a fully satisfactory yield of the petroleum products being sought, the practice nevertheless does not result in fullest exploitation of a producing field. This is true because during drilling, in an effort to reach a richly productive lower strata, the bore is passed through less rich higher horizons which for practical considerations are ignored. When the well subsequently is cased, which usually takes place as the drilling progresses, these higher less productive strata are effectively shut off and sealed, thus precluding their contribution thereafter to the production of the well unless the casing is perforated.

When a well, drilled as above described, has been producing for a period depending in length upon the geological character of the field, the rich highly productive lower strata are reduced to dry or at least non-productive condition and it then is desirable to tap higher less rich horizons in order the better to exploit the natural resources of the locality. This is especially desirable in view of the considerable cost of and time required for drilling a well bore, some of which extend several miles beneath the earth's surface. However, the tapping of higher horizons from an exhausted well, particularly a cased well, presents several important obstacles which it is necessary to overcome and which hitherto have effectively obstructed progress in this direction. For example it is necessary to determine accurately the limiting levels of the higher horizons in order that the casing may be perforated at the proper depth. Precision of depth measurement is of major importance in this particular

because if the casing is perforated at an incorrect depth the bore may be filled with salt water, or natural gas, which normally would facilitate oil flow into the well, escapes. However, the presence of the casing precludes determination of the character of adjoining strata by many of the conventional methods of well logging which are completely satisfactory for examination of uncased well bores. It is apparent then that if the higher horizons are to be located, a method of exploration must be employed which can be performed within a cased well or, alternatively, a record must be made of the character of the subsurface strata during the drilling of the well. For practical reasons, especially the limited time available for testing, a record of the last mentioned type seldom is made. Accordingly, in most instances, a method of exploration such as gamma ray well logging is relied upon for location of the desired strata. Gamma ray well logging is especially suited for this purpose because of the transparency of iron and steel to short wave length radiation which permits obtaining a log of surrounding geological formation irrespective of the presence of the casing. Even after having located with accuracy the depth of the higher less productive horizons, it then becomes necessary to provide means for perforating the well casing at exactly the proper levels. When this is attempted, new problems arise because of limitations of equipment now available. For example, when the limiting levels of the horizons are determined by movement of a geophysical prospecting instrument within the well bore, it is extremely difficult to obtain an exact measurement of the location of the instrument while suspended in the well because of stretching of the cable. A similar problem arises when a casing perforator is lowered into a well because in this instance too there is stretching of the suspending cable thereby making it difficult to locate accurately the position of the instrument within the well bore. It thus becomes necessary to calibrate empirically both the perforator and prospecting instrument assemblies in order that the level detected by the latter may be perforated by the former. Succession logging and perforation however are inherently disadvantageous because of the time required for first moving the prospecting instrument within the well and thereafter moving the perforator to the proper position.

A need accordingly has been experienced in the well logging art for an instrument which would permit simultaneous logging and perforation, thus assuring proper positioning of the perfora-

tor and obviating the necessity of lowering and raising the logging device before lowering the perforator.

A combination instrument comprising a casing perforator and a suitable geophysical prospecting device would appear to satisfy this need and to overcome the hereinabove mentioned difficulties. However, in this instance equally important difficulties, although of a somewhat different nature, are encountered. For example most of the casing perforators now employed are operated by explosion of a powder charge which fires a projectile through the casing wall, hence the perforator unit is subject to considerable recoil action which would damage or at least render useless delicate geophysical apparatus closely associated therewith. Furthermore, the transmittal of indications from the prospecting instrument to a recorder located at the surface and operation of the perforator unit from a surface control panel in accordance with present day practice would necessitate the use of a multi-conductor cable for each instrument in addition to the cable used for suspending the apparatus within the well bore. Although it is possible to combine these several cables into a special single cable, experience indicates that it is not advantageous to do so because firstly, special cables of this type are extremely costly as they must be constructed with special insulations capable of resisting the high hydrostatic pressures encountered within the well bore that would destroy ordinary insulation, and secondly because the cables must be relatively small in diameter although capable of supporting relatively large loads. The importance of this last factor will be apparent upon consideration that the apparatus may be used at a depth of ten to fifteen thousand feet or more within the well bore, in which instance the cable alone will weigh thousands of pounds, and will support in addition the relatively heavy instruments for prospecting and perforating. Under these conditions, which arise from the limitations from available equipment, the use of a combination perforator and prospecting device in the logging of cased wells has not been considered feasible.

The present invention provides a combination perforator and geophysical prospecting device which permits accurate placement of casing perforations and which overcomes the above mentioned difficulties.

The device according to this invention, in its preferred form, comprises a geophysical prospecting instrument, particularly one of the gamma-ray sensitive type, a perforator operable by electrical impulses, said instrument and perforator being physically substantially isolated from each other, for example by being housed in separate capsules connected by a short length of cable, and a common electrical circuit associated with the instrument and the perforator whereby impulses from the former can be received at the surface and impulses transmitted from the surface can operate the perforator.

To facilitate a better understanding of the device according to this invention and its mode of operation a specific embodiment thereof is illustrated in the accompanying drawing but it is clearly to be understood that this embodiment is disclosed by way of illustration of the practice of this invention and not by way of limitation thereof.

In the drawing a well bore A, provided with a casing B, is illustrated, within which a casing wall perforating device generally designated by 75

the reference character C and a geophysical prospecting instrument D are suspended upon a suitable cable E.

The casing wall perforating device C comprises a metallic capsule 10, having pointed ends for facilitating movement of the same within the well bore and being internally divided by partitions 11 and 12 which define the ends of a chamber 13. A plurality of projectile guns 14, 15, 16 and 17 are mounted in a side wall of the capsule 10 and extend within the chamber 13 substantially as shown, whereby projectiles 18, 19, 20 and 21 may be fired into the casing B by ignition of the explosive charges 22, 23, 24 and 25 positioned in the breeches of the guns. The muzzles of the guns normally are protected by yielding covers or shields 26, 27, 28 and 29 which are of course destroyed when the projectiles are fired from the gun.

The projectiles 18, 19, 20 and 21 are fired by electrical fuses 30, 31, 32 and 33 which are connected to selective filters 34, 35, 36 and 37 respectively. It is to be understood that the filters are designed whereby each passes only a current of preselected frequency characteristic. Each of the filters is connected to conductors 38 which form a part of the cable E and which are extended into the interior of the chamber 13 essentially as illustrated. It is to be understood from the foregoing that the projectiles 18, 19, 20 and 21 can be selectively fired singly or simultaneously or in any desired combination by transmitting currents into the conductors 38 having frequency characteristics corresponding to the filters 34, 35, 36 and 37.

The illustrated geophysical prospecting device D comprises the metallic capsule 40, pointed at its ends to facilitate movement within the well and internally subdivided by a partition 41 to define a gas tight chamber 42 within the bottom portion of the capsule. A pair of electrodes 43 and 44 of the type conventionally used in radiation sensing devices such as Geiger-Müller counters and high pressure ionization chambers, are mounted within the chamber 42 and connected in series with a battery 45 and a resistor 46. The chamber contains an appropriate dielectric such as nitrogen, argon or the like at a suitable pressure such that a current can flow from one electrode to the other under conditions of use. The signal generator and modulator 47 is connected whereby it receives an input signal from the conductors 48 connected to the resistor 46 and transmits a signal through the conductors 49 to the conductors 38 in the perforator capsule C. It is to be understood that the signal transmitted to the conductors 49 comprises a carrier-wave of preselected frequency differing from the passage frequencies of the filters 34, 35, 36 and 37, modulated proportionally to indications received from the prospecting device.

The modulated carrier-wave signal from the prospecting device D is transmitted through the conductors associated with the cable E to a filter-demodulator unit 50 located at the surface whereby a current is transmitted to a galvanometer 51 proportionally related to the indications received from the prospecting device. The galvanometer 51 reflects an image of a light source 52 onto a photosensitive web 53 carried on rollers 54 and 55. The web is moved continuously during movement of the perforator and prospecting device within the well bore by a suitable power transmission, such as a shaft 56 carrying a pulley 57 engaging with the cable

E. By this means a continuous record is provided upon the web of variations in geophysical character of strata explored by the prospecting device, correlated with motion of the prospecting device within the well bore. It thus will be apparent that by inspection of the well log appearing upon the web it is possible to determine a suitable depth for perforation of the casing to tap a selected horizon.

A plurality of oscillators 60, 61, 62 and 63, providing electrical currents of frequencies corresponding to the passage bands of the filters 34, 35, 36 and 37, are connected through switches 64, 65, 66 and 67 with the conductors associated with the cable E. Operation of the switches causes currents of the selected frequencies to be sent through the conductors and the corresponding filters to detonate the charges in the several guns, thereby firing the projectiles 18, 19, 20 and 21 in a manner determined by the operator. It will be apparent that the projectiles can be fired in any desired manner by operation of the corresponding switches and hence may be fired singly, simultaneously or in any selected combination.

In use, the unit comprising the perforator C and the prospecting device D is moved within the well bore A by operation of the winch 68 upon which the cable E is received. As the unit is moved within the well bore, the well log appearing upon the moving web 53 is continuously examined. When the log indicates the presence of a suitable horizon, the unit is shifted slightly within the well corresponding to the difference in position between the sensing device and the perforator and a perforation of the well casing is made by closing one or more of the switches 64, 65, 66 and 67. By this means extreme accuracy of perforation and exact correlation between the observations made and the perforation of the casing is possible.

In some instances it is desirable, during the logging of a well, to provide a subterranean reference point useful as an index of the location of surrounding geophysical formations. It is possible in practicing this invention to use projectiles containing readily detectable quantities of radioactive material, either naturally so or artificially induced, and by firing projectiles containing these substances at suitable locations within the well, points may be established which may be readily detected by ordinary radioactivity well logging methods.

I claim:

1. A geophysical prospecting device that comprises a radiation detector, a well casing perforator, and an electrical circuit including both the detector and the perforator capable of simultaneously receiving signals from the former and operating the latter by means of electrical currents having different operating characteristics.

2. A geophysical prospecting device that comprises means for detecting radiation from within a well bore; means for creating signals functionally related to the detected radiation, said signals having a preselected characteristic; means for perforating a well casing, including means for operating said perforating means in response to signals of different characteristics; means for suspending both said detecting and said perforating means within a well bore; a common electrical circuit associated with the detecting and the perforating means; and means at the surface, connected to said circuit, capable of simultaneously receiving indications from the

detecting means and operating the perforating means.

3. A geophysical prospecting device that comprises a radiation detector, a well casing perforator, a cable for suspending both the perforator and the detector within a well bore, an electrical circuit including both the detector and the perforator capable of simultaneously receiving signals from the former and operating the latter, and means for imparting to the signal current and to the casing perforator operating current different characteristics so that neither substantially affects the operation of the other.

4. A geophysical prospecting device capable of movement within a well bore comprising a prospecting instrument for transmitting electrical signals concerning significant characteristics of neighboring geological strata, an electrically operable gun and a projectile for the same, a common electrical circuit capable of simultaneously transmitting the signals and operating the gun, and means for providing signal currents and gun operating currents having different frequency characteristics.

5. A geophysical prospecting device that comprises at least one electrically operable projectile-firing unit, a selective band pass filter connected to said unit for operating the same when a current of suitable frequency is transmitted to the filter; means for detecting a significant characteristic of a neighboring geological formation; means for creating signals in accordance with the operation of the detecting means, said signals being of a frequency other than that capable of operating the projectile firing unit; and a common electrical circuit including said signal creating means and said filter for receiving signals from the former and capable of simultaneously independently operating the projectile-firing unit.

6. A geophysical prospecting device comprising a capsule adapted to be moved within a well bore, within said capsule a radiation detector including an ionization chamber through which a current flows related proportionally to radiation impinging thereon; an electrical circuit for carrying a signal having a preselected frequency characteristic and related to said current to instruments located at the surface; and well casing perforating means operable by electrical impulses of selected frequency characteristics other than said signal frequency characteristics simultaneously flowing in said circuit.

7. A geophysical prospecting device comprising a capsule adapted to be moved within a well bore, within said capsule a radiation detector including an ionization chamber through which a current flows related proportionally to radiation impinging thereon; an electrical circuit for carrying a signal related to said current to instruments located at the surface; and well casing perforating means operable by electrical impulses of selected characteristics, simultaneously flowing in said circuit, said perforating means including a series of projectile-firing guns and discriminating filters for controlling firing of said guns by electrical impulses in said circuit.

8. Method of geophysical prospecting that comprises measuring radiation emanating from a geological formation, transmitting in an electrical circuit signals corresponding to said measurements, and simultaneously transmitting in the same circuit electrical currents for selectively operating a plurality of projectile-firing instruments located in the vicinity of the radia-

tion measuring device, each of said last-named electrical currents and said radiation measurement signals having different characteristics for providing mutually independent operation of the radiation measuring instrument and the projectile-firing instruments.

9. Method of geophysical prospecting that comprises measuring within a well bore radiation emanating from surrounding geological formations, transmitting in an electrical circuit signals having a preselected frequency characteristic corresponding to the measurements, and simultaneously transmitting in said electrical circuit at least one current having a different frequency characteristic for selectively operating at least one projectile-firing instrument located in the vicinity of the radiation measuring device.

10. Method of geophysical prospecting that comprises measuring a significant characteristic of geological formations being examined, trans-

mitting in an electrical circuit impulses corresponding to the measurements, said impulses having a preselected frequency characteristic, and simultaneously transmitting in the same circuit electrical currents having frequency characteristics different from that of said impulses for operating at least one projectile-firing instrument located in the vicinity of the measuring means.

11. Method of geophysical exploration that comprises measuring within a well bore gamma radiation from neighboring geological structures, transmitting in an electrical circuit signals having a preselected frequency characteristic corresponding to the measurements, and simultaneously transmitting in said circuit at least one current having a different frequency characteristic for selectively operating at least one projectile-firing instrument located in the vicinity of the radiation measuring device.

ROBERT EARL FEARON.