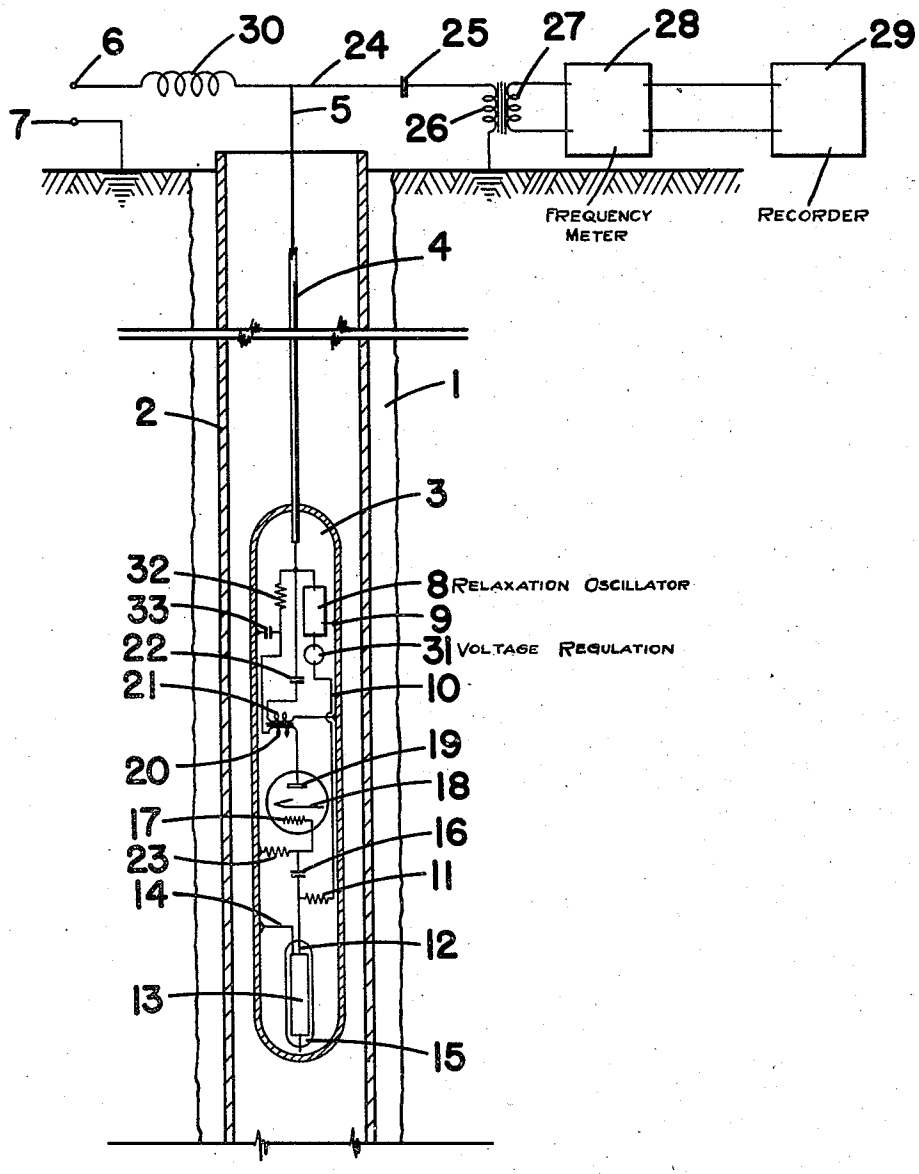
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APPARATUS FOR LOGGING BOREHOLES

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APPARATUS FOR LOGGING BOREHOLES

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The present invention is directed to a method and apparatus for logging boreholes, particularly cased boreholes, by measurement of the gamma-ray intensity along the borehole.

An object of the present invention is the provision of an apparatus of the character described in which a source of D. C. power is provided at the surface and means are provided in the borehole bomb for stepping up this D. C. voltage so as to provide the necessary voltage for operation of the gamma-ray detector.

An additional object of the present invention is the provision of means in the borehole bomb of an apparatus of the type referred to for conveying the pulses generated by gamma-rays back to the surface by the same conductor which is utilized for conveying the power to the bomb.

Another object of the present invention is the provision of a circuit in the bomb which permits the utilization of the source of power at the surface for the operation of an amplifier, as well as the operation of the gamma-ray sensitive device in the bomb. One of the principal advantages of the circuit which constitutes the present invention is the elimination of the need for batteries in the borehole bomb aside from the small batteries which provide the filament voltage in the amplifier. This is an important advantage when one considers that a high voltage is ordinarily necessary for the operation of the gamma-ray detector and that the batteries required for supplying this voltage would take up considerable space in the bomb.

Further objects and advantages of the present invention will appear from the accompanying drawing in which the single figure is a vertical section, partly in diagrammatic form, of the apparatus of the present invention in place in a borehole.

Referring to the drawing in detail, numeral 1 designates a borehole provided with metallic casing 2. The gamma-ray sensitive device is contained in a bomb 3 made of steel or other pressure-resistant material of sufficient thickness to withstand pressures encountered in the borehole. The bomb 3 is suspended on a cable 4 carrying a single conductor 5. This conductor is connected at the surface to one terminal 6 of a source of D. C. power, the other terminal 7 of which is grounded.

The conductor 6 is connected in the casing to the input terminal of a relaxation oscillator designated by the square 8. This oscillator may be one of the number of well known relaxation oscillators which serve the purpose of stepping up a supply voltage. One type of relaxation oscillator which is useful in the apparatus of the present invention is illustrated in Fig. 5 of an article entitled "A Portable High Voltage Supply," by R. D. Huntoon, appearing in the June 1939 issue of Review of Scientific Instruments, at pages 176–178.

The relaxation oscillator has a ground connection 9 and an output lead 10 which is connected through a resistance 11 to the anode 12 of a Geiger Muller counter which is also provided with cathode 13 which is grounded through lead 14. It will be understood that these electrodes are contained in a chamber 15 which may be glass walled. The anode 12 is connected through a condenser 16 to the grid 17 of an amplifying tube, which is provided with the usual filament 18 having the customary voltage supply which is not shown. The plate 19 of this tube is connected to one terminal of a winding 20 of a transformer, the other terminal of which is connected to conductor 5 above the relaxation oscillator. The other winding 21 of the transformer is a low impedance winding and has one of its terminals grounded to the wall of the bomb 3 and its other terminal connected through a condenser 22 to conductor 5 above the relaxation oscillator. Between the condenser 16 and the grid 17 is a resistance 23 connected to ground which is provided to regulate the action of the grid.

At the surface the conductor 5 is connected by a line 24 through a condenser 25 to a low impedance winding 26 of a transformer, the other winding 27 of which has its terminals connected to a frequency meter 28, the output of which is fed into recorder 29. It will be understood that this recorder is usually of the photographic type in which a beam of light controlled by the output of the frequency meter is caused to play on a sensitized strip of paper, the movement of which is synchronized with the movement of the bomb in the borehole so that the measurements made may be correlated with depth. All of this recording and correlation system is well known in the art and is not described in detail here since it forms no part of the present invention.

At the surface between terminal 6 and branch line 24 conductor 5 contains a coil 30 which serves to prevent the grounding of signals coming up the conductor 5 through the D. C. source of power, and forces the signals through the line 24. It may be mentioned here that in the bomb there is, in practice, usually provided in line 10 a voltage regulator, indicated by a circle 31. This voltage regulator serves the purpose of keeping the volt-

age impressed across the electrodes of the Geiger Muller counter fairly constant and may be any one of several known types of voltage regulators. A suitable type for use in this capacity is the neon tube type, a description and illustration of which may be found in an article entitled "Voltage Sources and Amplifiers for Geiger Counters," by H. S. Gingrich, appearing in the May 1936 issue of Review of Scientific Instruments, vol 7, pages 207–210.

In practice, the D. C. voltage supplied at terminals 6 and 7 may vary within a wide range from about 30 volts to about 200 volts. The minimum voltage will usually be determined by the voltage required to operate the relaxation oscillator. In a typical case, a voltage of about 140 was maintained between terminals 6 and 7, and the relaxation oscillator stepped this voltage up sufficiently to establish a potential difference between the electrodes in the Geiger Muller counter of about 1,000 volts.

As the Geiger-Muller counter is lowered into the well and subjected to the gamma-rays emanating from the formations surrounding the borehole, it gives off periodic pulses, the frequency of which is a function of the gamma-ray intensity. These pulses therefore have the characteristics of an alternating current, which makes it possible for them to pass through condenser 16 to the grid 17. These pulses produce amplified pulses in the plate circuit which pass through the winding 20, which is the high impedance winding of the transformer.

These pulses, in turn, induce pulses in the low impedance winding 21, the impedance of which is matched with the impedance of winding 26 at the surface. It may be mentioned here that, if desired, any effect of the pulses which pass through winding 20 on the recording apparatus can be eliminated by including in the bomb in the line connecting winding 20 to conductor 5 a filter comprising a resistance 32 and a condenser 33 which prevent any pulses from the winding 20 from reaching conductor 5. This filter also serves to keep line noises out of the secondary 21.

It will be apparent that changes can be made in the arrangement of parts shown without departing from the fundamental principles upon which the present invention is based. As has already been indicated in the foregoing description, many of the electrical elements shown are for illustrative purposes only and can be replaced by other electrical elements capable of performing the same function.

The nature and objects of the present invention having been thus described and illustrated, what is claimed as new and useful and is desired to be secured by Letters Patent is:

1. An apparatus for logging boreholes comprising a Geiger-Muller counter adapted to be lowered into a borehole, a source of D. C. power at the surface for operating said Geiger-Muller counter, a single conductor cable for conducting said D. C. power from the surface to said counter, means arranged in the circuit between said source of power and said counter and adapted to move with the counter for stepping up the voltage supplied by said D. C. source to the value required for operation of said counter, means connecting the output of said counter to said single-conductor cable, means at the surface for separating the output pulses of the counter from the applied D. C. and means at the surface for recording the output pulses of said counter.

2. An apparatus for logging boreholes comprising a Geiger-Muller counter adapted to be lowered into a borehole, a source of D. C. power at the surface for operating said Geiger-Muller counter, a single-conductor cable connecting said source of power to said counter, means connecting the output of said counter to said single conductor cable, means at the surface for separating the output pulses of the counter from the applied D. C. and means at the surface for recording the output pulses of said counter.

3. An apparatus for logging boreholes comprising a bomb adapted to be lowered through the borehole, a Geiger-Muller counter arranged in said bomb, a relaxation oscillator arranged in said bomb having its output connected across the electrodes of said Geiger-Muller counter, a source of D. C. power at the surface connected to the input of said relaxation oscillator, means for transmitting the output pulses of the Geiger-Muller counter to the surface, and means for recording said pulses at the surface.

4. An apparatus for logging boreholes comprising a bomb adapted to be lowered in the borehole, a Gieger-Muller counter in said bomb, a relaxation oscillator in said bomb having its output connected across the electrodes of said Geiger-Muller counter, a vacuum tube amplifier connected to the output of said Geiger-Muller counter, a D. C. source of power arranged at the surface, means for connecting said source of power to the input of said relaxation oscillator and to the plate of said amplifier, a transformer having its primary arranged in the plate circuit of said amplifier, a recorder for pulses at the surface, and means connecting the secondary of said transformer to said recorder.

5. An apparatus for logging boreholes comprising a bomb adapted to be lowered into a borehole, a Geiger-Muller counter arranged in said bomb, a relaxation oscillator arranged in said bomb with its output connected across the electrodes of said counter, a vacuum tube amplifier connected to the output of said counter, a source of D. C. power at the surface, a single conductor cable connecting said source to said bomb, means connecting said single conductor to the input of said oscillator and to the plate of said amplifier, a transformer having its primary in said plate circuit, means connecting the secondary of said transformer to said single conductor, and a recorder for pulses arranged at the surface inductively connected with said single conductor.

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