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(54) CIRCUITRY FOR MONITORING A HIGH DIRECT CURRENT VOLTAGE SUPPLY FOR AN IONIZATION CHAMBER

(71) We, SIEMENS AKTIENGESELLSCHAFT, a German company of Berlin and Munich, Germany, do hereby declare the invention for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

This invention relates to circuitry for monitoring a high direct current voltage supply for an ionization chamber.

It is known in the case of radiation plants of the most varied kind to switch these off via an ionization chamber exposed to the radiation as soon as a pre-set dose of radiation has been applied. Moreover, in the case of particle accelerators it is known to regulate the radiation output via the ionization current of an ionization chamber exposed to the radiation, so that the number of radiation pulses per unit of time is altered to correspond to the measured chamber signal. The travel time of the ions produced in the chamber volume of the ionization chambers is dependent on the spacing of the electrodes and also on the voltage lying at the electrodes. Because of the limited life of the ions, their travel time in the chamber volume must be limited to a maximum by reducing the electrode spacing and/or by increasing the voltage lying at the electrodes, so that too high a loss, which would falsify the measurement, does not occur through recombination. The proportionality of the current flowing through the ionization chamber to the dose output applied in the chamber volume remains constant when the supply voltage rises further, until the electrical field intensity reaches a value at which the ions are accelerated so strongly that, with the medium, free path length which is dependent on the chamber pressure, they acquire as much energy as is required for the ionization of further gas atoms. Ionization chambers, therefore, are operated in this proportional voltage zone because here fluctuations of the supply voltage have no effect of the result of the measurement. In the case of very high dose outputs however, such as are present in the radiation pulses of particle or electron accelerators respectively, considerable inaccuracies of measurement were found. This is of considerable disadvantage if the result of the measurement is used for adjusting the accelerator output, i.e. for adjusting the number of the radiation pulses per unit of time.

According to the present invention there is provided circuitry for monitoring a high direct current voltage supply for an ionization chamber, the circuitry comprising a voltage measuring arrangement for measuring the voltage of such a voltage supply, and switching means connected with and controlled by the measuring arrangement, wherein the voltage measuring arrangement comprises:

first and second signal coupling means, each being provided with an input and an output such that, in use, the output is responsive to signals at the input, there being no electrically conductive path between the input and the output, and the input of the second signal coupling means being connected in series with the output of the first signal coupling means, which input of the second signal coupling means is adapted for connection with the voltage supply to be monitored;

pulse generating means connected with the input of the first signal coupling means;

a load resistance connected, between the output of the second signal coupling means and an input for a power supply for the measuring arrangement;

discriminating means, an input of which is connected in parallel with the load resistance, the discriminating means being responsive in use to voltages, at the load resistance, having values above a predetermined value; and

direct current blocking means connected between an output of the discriminating means and the switching means.

The first and second signal coupling means could each comprise an optocoupler, a respective luminescent diode and phototransistor forming the input and output respectively of each optocoupler. Alternatively, the first and second signal coupling means could each comprise a Hall generator, field plates, or an isolating transformer.

The blocking means could comprise first and second series-connected diodes, the first diode being connected in a conduction direction with respect to the discriminating means and the second diode being connected in a blocking;

direction with respect to the discriminating means, and an inductance connected between the junction of the first and second diodes and earth.

The switching means preferably comprises a relay.

The discriminating means preferably comprises a Schmitt trigger.

The circuitry could further be provided with an alternating current amplifier connected between the discriminating means and the blocking means.

The circuitry could be used in combination with an ionization chamber, the circuitry being arranged for monitoring a high direct current voltage supply of the ionization chamber. Such circuitry could be used in combination with a particle accelerator, the ionization chamber being arranged to monitor the radiation output of the particle accelerator.

The invention will now be described, by way of example, with reference to the single figure of the accompanying drawings which shows a circuit diagram of circuitry for monitoring a high direct current voltage supply for an inonization chamber.

Referring to the left hand side of the figure, a high resistance voltage divider 1, 2 is connected with a high voltage source (not shown). and a capacitor 3 is connected in parallel with a resistor 2 of the voltage divider 1, 2. A phototransistor 4 of a first optocoupler 5 is connected in series with a luminescent diode 6 of a second optocoupler 7, a protective resistor 8 and the capacitor 3. A luminescent diode 9 of the first optocoupler 5 is connected to a pulse generator 10. The phototransistor 11 of the second optocoupler 7 is connected to a load resistance 12 and to the input of a discriminator 13. The output of this discriminator 13 is connected to the base of a semi-conductor switch 15 *via* an amplifier 14. The collector-emitter stage of the semi-conductor switch 15 is connected in series with a device 16 which blocks direct boltage components, and with a relay 17 to be controlled. The device 16 comprises two series-connected diodes 18 and 19, one of which is connected in a forward direction and the other in a blocking direction, their common terminals being connected *via* an inductance 20 to earth. For the purposes of smoothing a capacitance 21 is connected in parallel with the relay 17 to be controlled.

As soon as a high voltage is across the voltage divider 1, 2 it charges the capacitor 3 connected in series with the photo-transistor 4 of the first optocoupler 5, the luminescent diode 6 of the second optocoupler 7 and the protective resistor 8. When the pulse generator is operating it produces short pulses of light from the luminescent diode 9 of the first optocoupler 5. The conductivity of the phototransistor 4 is alternately increased at the frequency of these light pulses. The capacitor 3 is discharged *via* the phototransistor 4 of the first optocoupler 5 and *via* the luminescent diode 6 of the second optocoupler 7. The phototransistor 11 of the second optocoupler 7, which is connected to a supply voltage of the measuring arrangement, becomes alternately conductive by means of light pulses produced by the luminescent diode 6. As the luminescent diode is dependent on the voltage supplied to it, the intensity of the pulses of light depends on the voltage lying at the capacitor 3, i.e. the voltage tapped off by the voltage divider 1, 2. Therefore, the resistance value, reached by pulsing by the phototransistor 11 of the second optocoupler 7, also depends on the voltage lying at the capacitor 3 which is proportional to the high voltage supplied to the voltage divider 1, 2. Only those pulses which attain a pre-settable minimum value are allowed through the discriminator 13, the input of which is connected in parallel with the load resistor 12 of the phototransistor 11 of the second optocoupler 7. The pulses allowed through the discriminator 13 are amplified by the amplifier 14, which is connected to the output side of the discriminator 13, and fed to the base of a semi-conductor switch 15. The inductor 20 is supplied at the frequency of the pulses passed *via* this semi-conductor switch 15. The first diode 18 permits the magnetic field formed in the inductor 20 to be removed between successive pulses in each case only *via* the other diode 19, and thus may charge the capacitor 21 connected in parallel with the relay 17.

As soon as the value of the high voltage falls below a predetermined value set at the discriminator 13, the luminous power of the luminescent diode 6 also falls to a value which makes the phototransistor 11 of the second optocoupler 7 so weakly conductive that the pulses arriving at the input of the discriminator 13 have too low an amplitude to be passed by the discriminator 13. Because of this, the semiconductor switch 15 remains blocked and the inductor 20 is no longer supplied. When the value of the capacitor 21 is adjusted according to the resistance value of the relay, the voltage across the capacitor 21 falls within one cycle to a value which lies, in this case, below the self-holding voltage value of the relay 17. Almost any short decay times can be achieved by the corresponding selection of the frequency produced by the pulse generator 10. Thus, the hysteresis of the relay 17 is no longer of any importance. The switching time which can be achieved is still dependent only on the slowness of the switch 17 which is employed.

Should one of the devices such as the pulse generator 10, an optocoupler 5 or 7, the discriminator 13, the amplifier 14 or the semi-conductor switch 15 fail, alternating signals are no longer transmitted. It is immaterial whether possibly faulty transistors are normally conductive or blocking. As only alternating voltage components are used for supplying the relay 17, no signal is produced in all these cases and the relay 17 remains in the same position that it would occupy if a sufficiently high voltage is not present. In this position of the relay 17 (as shown in the Figure) a particle accelerator 22 is not switched on or off. Instead, an indicator device 23 for indicating a fault is switched on via one of the changeover contacts of the relay 17.

The conductive isolation of the high voltage may also be achieved by means of isolating transformers, Hall genreators and field plates, instead of using optocouplers. In place of the device 16 a single large capacitor could be used to block direct voltages, which capacitor could be connected between the semi-conductor switch and the relay 17.

Using the circuitry described above, the signal of an ionization chamber is only evaluated when the high voltage supply has reached a minimum value. This minimum value is, where possible, in the proportional region of the ionization chamber. It is almost identical to the rated value of the high voltage. Because of the constructionally limited voltage stability of the ionization chamber on the one hand, and the high dose output density on the other hand, in practice the signal of the ionization chamber is dependent on the voltage present. In the case of the high voltage supplied to the ionization chamber and maintained at a specific value and the dose output which is constant for each radiation pulse, the ionization current can also be adjusted to dose values when the ionization chamber is operated outside its proportional region. As a result of the conductive isolation of the measuring arrangement for the high voltage, faulty measurements of the dose output, which can be cuased by voltages induced in earth circuits, are avoided. Because of the fast readjustment of the dose output required in the case of electron accelerators, a largely hysteresis-free measurement is essential.

WHAT WE CLAIM IS:

1. Circuitry for monitoring a high direct current voltage supply for an ionization chamber, the circuitry comprising a voltage measuring arrangement for measuring the voltage of such a voltage supply, and switching means connected with and controlled by the measuring arrangement, wherein the voltage measuring arrangement comprises:

first and second signal coupling means, each being proved with an input and an output such that, in use, the output is responsive to signals at the input, there being no electrically conductive path between the input and the output, and the input of the second signal coupling means being connected in series with the output of the first signal coupling means, which input of the second signal coupling means is adapted for connection with the voltage supply to be monitored;

pulse generating means connected with the input of the first signal coupling means;

a load resistance connected, between the output of the signal coupling means and an input for a power supply for the measuring arrangement.

discriminating means, an input of which is connected in parallel with the load resistance, the discriminating means being responsive in use to voltages, at the load resistance, having values above a predetermined value; and

direct current blocking means connected between an output of the discriminating means and the switching means.

2. Circuitry according to Claim 1, wherein the first and second coupling means each comprise an optocoupler, a respective luminescent diode and photo-transistor forming the input and output respectively of each optocoupler.

3. Circuitry according to Claim 1, wherein thr first and second signal coupling means each comprise a Hall generator, field plates, or an isolating transformer.

4. Circuitry according to any preceding claim, wherein the blocking means comprises first and second series-connected diodes, the first diode being connected in a conducting direction with respect to the discriminating means and the second diode being connected in a blocking direction with respect to the discriminating means, and an inductance connected between the junction of the first and second diodes, and earth.

5. Circuitry according to any preceding claim, wherein the switching means comprises a relay.

6. Circuitry according to any preceding claim, wherein the discriminating means comprises a Schmitt trigger.

7. Circuitry according to any preceding claim, further comprising an alternating current amplifier connected between the discriminating means and the blocking means.

8. Circuitry for monitoring a high direct current voltage supply for an ionization chamber substantially as herein described with reference to the accompanying drawing.

9. Circuitry according to any preceding claim, in combination with an ionization chamber, the circuitry being arranged for monitoring a high direct current voltage supply of the ionization chamber.

10. Circuitry according to Claim 9, in combination with a particle accelerator, the ionization chamber being arranged to monitor the radiation output of the particle accelerator.

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1600533 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*