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(54) IMPROVEMENTS IN OR RELATING TO A DEVICE FOR SCANNING A TARGET WITH A BEAM OF CHARGED PARTICLES

(71) We, C.G.R.-MeV, a French Body Corporate, of Route de Guyancourt, 78530 BUC—France—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:—

The present invention relates to a device for scanning a target with a beam of charged particles, the device making it possible to modify the radiation dose received by the target which has a given position and given dimensions.

A scanning beam is produced by subjecting a beam of charged particles to the influence of an electric field or magnetic field whose amplitude is a time-variable function, the variations generally being periodic in nature (alternating sinusoidal or saw-tooth field for example). If the beam of particles is subjected to a magnetic field produced by a bi-polar electromagnet, scanning is obtained along a straight line whilst if the electromagnet is of the four-pole kind, the beam can scan an area. However, it should be pointed out that the position occupied by the particle beam at the entrance to the four-pole device, in relation to the latter's axis, determines the distribution of the radiation dose level received by the target. In other words, any eccentricity in the beam at the entrance to the scanning four-pole device, introduces a modulation in the dose level from one edge of the target to the other, the target being disposed perpendicularly to the axis of the four-pole device and being centred in relation thereto.

It is therefore possible to modulate the radiation dose received by a target, in a predetermined manner, by arranging for the beam to be eccentric at the entrance to the scanning four-pole device.

According to the present invention there is provided a device for performing a method of scanning, for scanning a target with a charged particle beam, said method being intended to produce a non-uniform scanning pattern, said device comprising a main magnetic system of axis Z–Z, a secondary magnetic system, of axis Z–Z, located up stream of said main magnetic system, and circuitry connected to said main and secondary magnetic systems and adjusted to provide necessary periodic signals for obtaining said scanning pattern, said periodic signals enabling said beam to be eccentrically positioned at the entrance of said main magnetic system during, at least, a part of a complete cycle of said main magnetic system.

The invention can best be understood by reference to the following description taken in connection with the accompanying illustrative drawings in which:

Figs. 1 and 2 respectively illustrate the figure scanned by a beam which in the one case is centred and in the other is located eccentrically in relation to the axis ZZ of a scanning system of known type, and also illustrate the variation in the radiation dose level obtained, using these respective beams, on a target disposed perpendicularly to the axis ZZ of this scanning system.

Fig. 3, in section, illustrates an example of a scanning device in accordance with the invention.

Fig. 4 schematically illustrates the supply circuits of the main and second magnetic systems of the scanning device in accordance with the invention.

Fig. 5 illustrates an example of two electrical signals which can be applied simultaneously to the coils of the main magnetic system and to the coils of the secondary magnetic system.

Fig. 6 illustrates the variation in the radiation dose level obtained on a target when electrical signals of the kind shown in Fig. 5 are used.

Figs. 7 and 9 respectively illustrate two other pairs of signals which can be applied to the main and secondary magnetic systems.

Figs. 8 and 10 respectively illustrate the modulations in radiation dose level produced using the signals shown in Figs. 7 and 9.

Fig. 1 illustrates a source S of charged particles emitting a particle beam F which is subjected to the action of a variable magnetic field created between the two polepieces A and B of an electromagnet, the polepieces respectively being associated with coils a and b connected to a voltage source V furnishing a signal of predetermined form.

If the beam F is centred on the axis ZZ of the scanning device, it can scan a target K disposed perpendicularly to said axis ZZ, along a straight line XX, the distribution of the radiation dose level being substantially constant. If, at the entrance to the scanning system, the beam F is disposed eccentrically in relation to the axis ZZ, the distribution of the radiation dose level, or in other words density, on the straight line XX is modulated and this modulation is a function of the eccentricity of the beam F.

The scanning beam obtained from a beam F centred on the axis ZZ has been shown in full line in Fig. 1 and that obtained from the eccentric beam has been shown in broken line (respectively beams u and v).

Fig. 2 illustrates the distribution in dose level, d_u and d_v, obtained on the target K for each of the beams u and v.

If the beam F has an eccentricity which is symmetrical to that indicated earlier, then a dose level distribution d_w which is symmetrical to that d_v, will be obtained.

The scanning device in accordance with the invention, shown in section in Fig. 3, enables the irradiation dose level received by the target K to be modulated by introducing a variable eccentricity of the radiation beam by respect with axis ZZ before it is subjected to the scanning signals proper. In this embodiment, the scanning device in accordance with the invention comprises a main magnetic scanning system so called main four-pole system Q_1 having four polepieces A_1, B_1, C_1, D_1, respectively equipped with coils a_1, b_1, c_1, d_1, supplied in pairs (a_1, b_1 and c_1, d_1) from a voltage source V. Upstream of this main four-pole system Q_1 there is provided a secondary magnetic system so called secondary four-pole system Q_2 having four polepieces A_2, B_2, C_2, D_2, respectively equipped with coils a_2, b_2, c_2, d_2 (only the polepieces A_1, B_1 and A_2, B_2 and their respective coils a_1, b_1 and a_2, b_2, are visible in fact in Fig. 3). An example of an arrangement for supplying these coils a_1, b_1; c_1, d_1 and a_2, b_2; c_2, d_2 has been shown schematically in Fig. 4. The supply arrangement comprises a control voltage source V_0 associated with:

— A voltage generator G_{x1} for the channel X_1 of the main four-pole system Q_1, this channel X_1 corresponding to the polepieces A_1, B_1 located in the axis X_1, X_1 of the main system Q_1;

— A voltage generator G_{y1} associated with the polepieces C_1, D_1 (channel Y_1 disposed on the axis Y_1Y_1 of the main system Q_1);

— Two amplifiers A_{x1} and A_{y1};

— A voltage generator G_{x2} associated with the pair of polepieces A_2 and B_2, corresponding to the channel X_2, located along the axis X_2X_2 of the secondary system Q_2;

— A voltage generator G_{y2} associated with the pair of polepieces C_2, D_2, corresponding to the channel Y_2, located along the axis Y_2Y_2 of the secondary system Q_2; and

— Two amplifiers A_{x2} and A_{y2}.

In operation, the two voltage generators G_{x1} and G_{y1} create two signals S_{x1} and S_{y1} (sawtooth signals for example) whose amplitudes are proportional to the control voltage V_0. The periodicities of the oscillations in the channels X_1 and Y_1 may differ from one another and be in a predetermined ratio to each other. The signals S_{x1} and S_{y1} are applied respectively to the coils a_1, b_1, c_1, d_1 after amplification in the amplifiers A_{x1} and A_{y1}. Simultaneously, the voltage generators G_{x2} and G_{y2} create two signals S_{x2} and S_{y2} (squarewave signals for example) which are applied, after amplification in the amplifiers A_{x2} and A_{y2}, to the coils a_2, b_2 and c_2, d_2 of the secondary system Q_2 Fig. 5, by way of non-limitative example, illustrates signals S_{x1} and S_{x2} which can be applied respectively to the pairs of coils a_1, b_1 and a_2, b_2. Signals S_{y1} and S_{y2} respectively similar to those S_{x1} and S_{y2}, are applied to the two other pairs of coils c_1, d_1 and c_2, d_2. In Fig. 6, the distribution of the radiation dose level received by a target K has been shown, the radiation beam F being subjected to the magnetic field developed by the signals S_{x2}, S_{y2} applied to the secondary four-pole system Q_2, and then to the magnetic scanning field developed by the signals S_{x1} and S_{y1}.

In another embodiment, the main and second four-pole systems can be connected in series and supplied from a single supply circuit. Fig. 7 illustrates the signals S_{x1} and S_{x2} which can be applied respectively to the four-pole systems Q_1 and Q_2 in this embodiment, whilst Fig. 8 illustrates the corresponding dose level modulation (full-line graph). The broken-line graph of Fig. 8 illustrates the dose level modulation obtained when the signals S_{x2} and S_{y2} are zero.

A modulation in dose level, or in other words density, which exhibits a peak at the centre of the distribution curve, as in the case of Fig. 10, can be obtained by producing a 180° phase shift between the signals S_{x1} and S_{x2} respectively applied to the four-pole systems Q_1 and Q_2 (Fig. 9).

This kind of scanning device can advantageously be used to compensate for defects in the uniformity of bombardment of a target by a beam of charged particles (edge defects of the kind presented for example by scanning beams comprising low-energy electrons, or deflects due to the beam collimation system).

This device, which is simple in design, is extremely flexible as far as its adjustment is concerned, and is highly reliable.

WHAT WE CLAIM IS:—

1. A device for performing a method of scanning, for scanning a target with a charged particle beam, said method being intended to produce a non-uniform scanning pattern, said device comprising a main magnetic system of axis Z–Z, a secondary magnetic system, of axis Z–Z, located upstream of said main magnetic system, and circuitry connected to said main and secondary magnetic systems and adjusted to provide necessary periodic signals for obtaining said scanning pattern, said periodic signals enabling said beam to be eccentrically positioned at the entrance of said main magnetic system during, at least, a part of a complete cycle of said main magnetic system.

2. A scanning device as claimed in Claim 1, wherein said main and secondary magnetic scanning systems are four-pole systems.

3. A scanning device as claimed in Claim 2, wherein said coils of the polepieces of said main and secondary four-pole systems are supplied in pairs, in series, by a supply circuit.

4. A scanning device as claimed in Claim 2, wherein said coils of the polepieces of said main and said secondary four-pole systems, are supplied by separate supply circuits.

5. A scanning device as claimed in Claim 4, wherein said supply circuit of said main four-pole system comprises two generators followed by two amplifiers respectively feeding the two pairs of coils of said mutually opposite polepieces corresponding to the two channels X_1 and Y_1, and said supply circuit of said secondary four-pole system comprises two other generators followed by two amplifiers respectively supplying the two pairs of coils of the mutually opposite polepieces corresponding to two channels X_2 and Y_2.

6. A scanning device as claimed in Claim 5, wherein said two supply circuits respectively supply signals S_{x1} and S_{y1} in the channels X_1 and Y_1, and signals S_{x2} and S_{y2} in the channels X_2 and Y_2, said signals S_{x1} and S_{y1} being sawtooth signals and said signals S_{x2} and S_{y2} being square-wave signals of the same periodicity.

7. A scanning device as claimed in Claim 6, wherein said signals S_{x2} and S_{y2} are respectively in phase with said signals S_{x1} and S_{y1}.

8. A scanning device as claimed in Claim 6, wherein said signals S_{x2}, S_{y2}, are respectively in phase-opposition with said signals S_{x1} S_{y1}.

9. A scanning device as claimed in Claim 3, wherein said supply circuit furnishes sawtooth signals, said signals applied to the coils of the mutually opposite polepieces belonging respectively to said main and secondary four-pole systems, being in phase with one another.

10. A scanning device as claimed in Claim 3, wherein said supply circuit furnishes sawtooth signals, said signals applied to the coils of the mutually opposite polepieces belonging respectively to said main and secondary four-pole systems, being in phase-opposition with one another.

11. A scanning device substantially as hereinbefore described with reference to the accompanying drawings.

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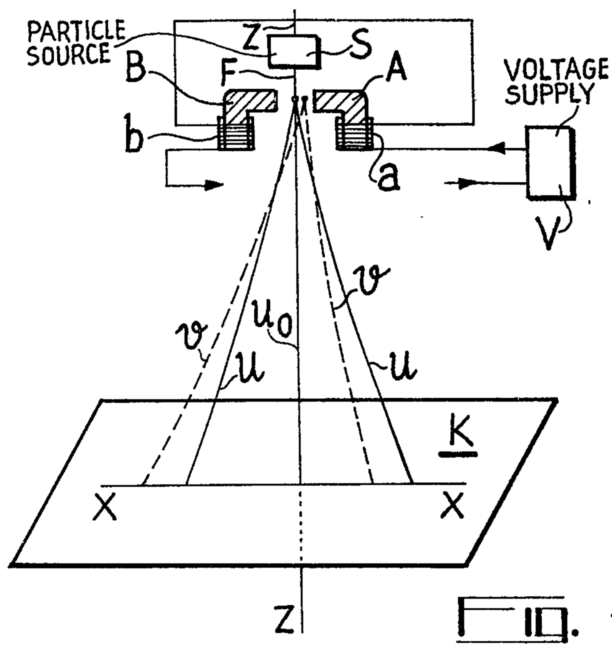
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FIG. 1

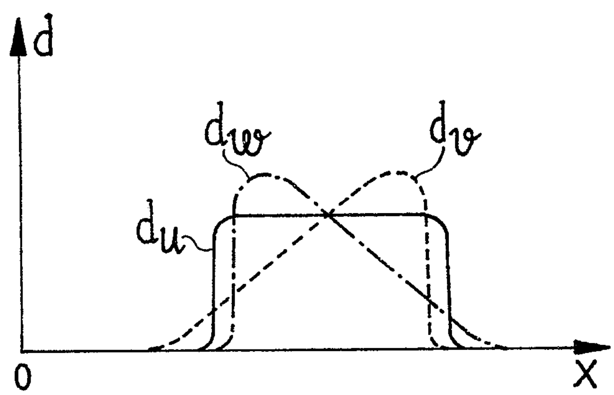
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FIG. 2

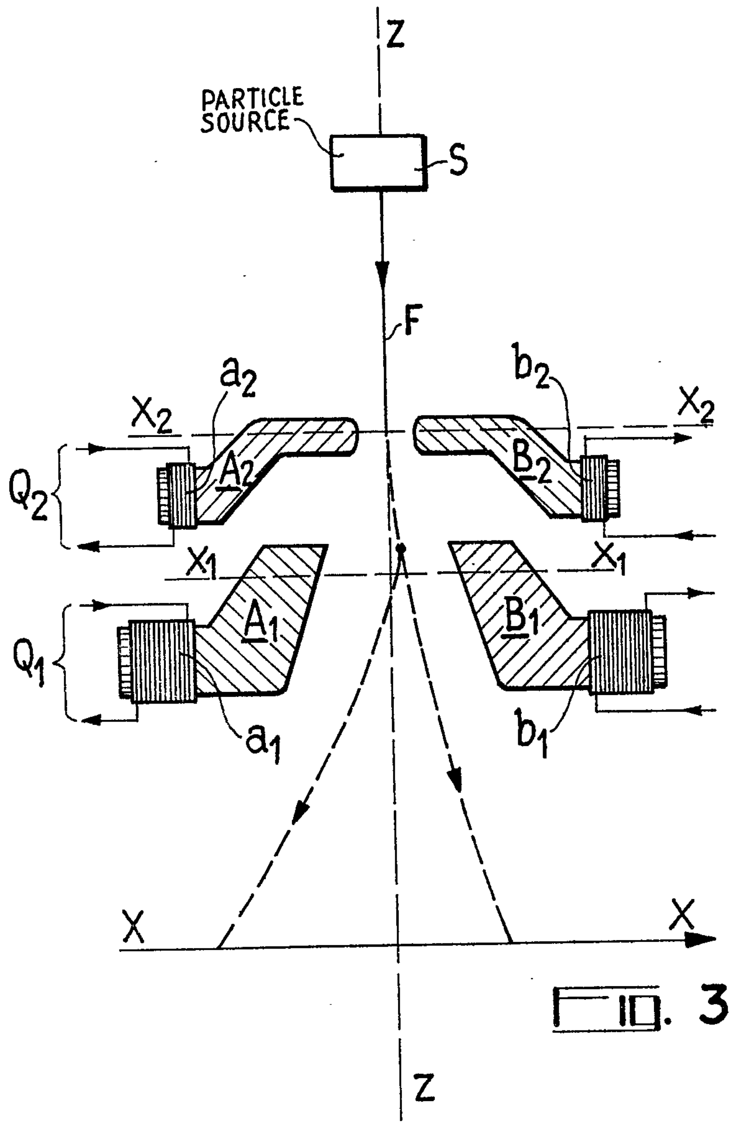

FIG. 3

1570314 COMPLETE SPECIFICATION

5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 3

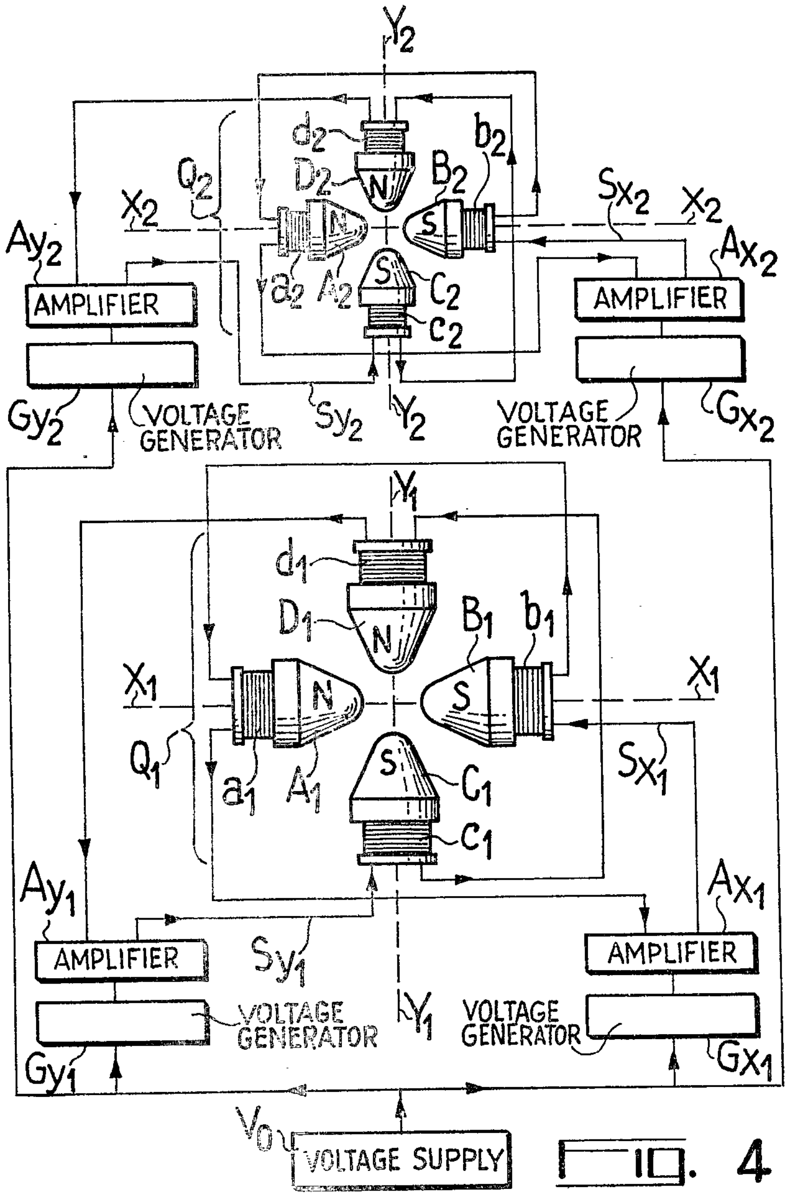

FIG. 4

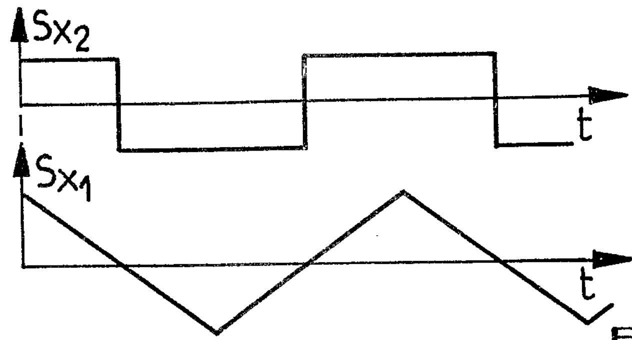

Fig. 5

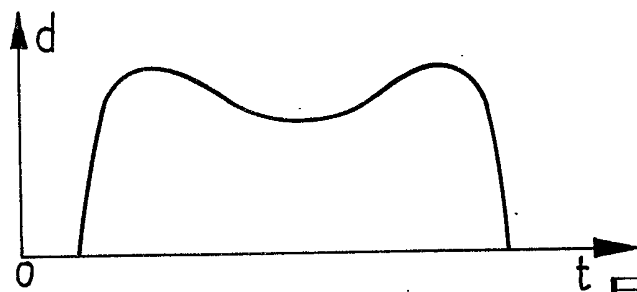

Fig. 6

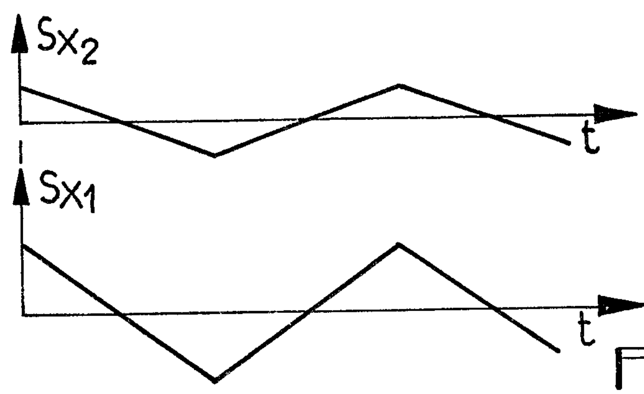

Fig. 7

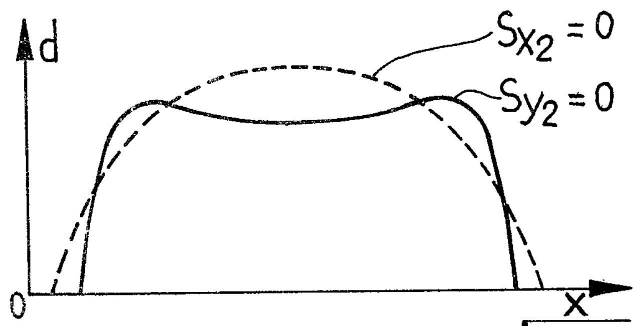

Fig. 8

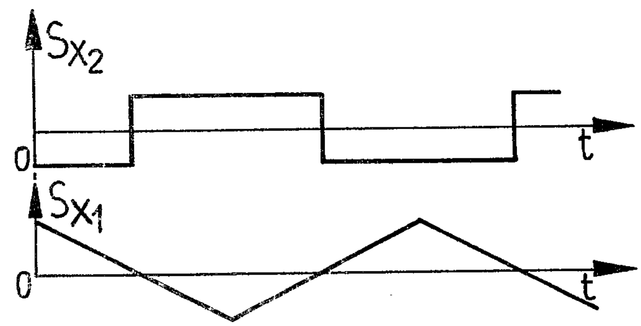

Fig. 9

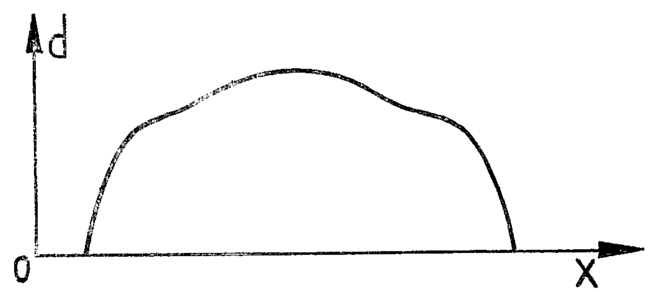

Fig. 10