The development of a continuous recording scintillation counter mounted on a cyclometer

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SYNOPSIS

In order to facilitate ground radiometric surveys the Atomic Energy Board has developed a continuous recording device attached to a scintillation counter which is mounted on a cyclometer.

Details concerning the construction are given.

SINOPSIS

Met die oog daarop om radiometriese opnames op die grond te vergemaklik, het die Raad op Atoomkrag 'n deurlopende registreertoestel ontwikkel wat aan 'n fietsteller geheg en op 'n siklometer gemonteer is.

Gegewens oor die konstruksie word verstrek.

INTRODUCTION

Radiometric surveys are a prerequisite for the prospecting for nuclear source materials; various techniques are used and improvements in method and instrumentation are continually being made.

Broadly speaking, the following three different techniques are employed. All have their special applications and inherent disadvantages.

1. Airborne surveys are carried out from an aircraft flying along predetermined flight lines about 1 km apart and at an elevation of about 100 metres above the ground. This technique has reached a considerable degree of refinement[1] and serves to locate radiometric anomalies relatively quickly. It is especially useful in rough terrain where communications are poor. However, this method cannot always be employed in mountainous or deeply dissected country because readings must, within certain tolerances, be taken at a fixed height above the ground. These problems may sometimes be overcome by using a helicopter.
2. Carborne surveys are undertaken either as a follow-up to airborne surveys or as a reconnaissance survey where airborne surveys have not been carried out. This technique is relatively cheap and fast, but obviously has serious limitations in rough terrain.
3. Ground radiometric surveys must eventually be carried out over any terrain which shows even marginal promise. Instrumentation has reached an elaborate degree of sophistication[2].

Fig. 1

*Geology Division: S.A. Atomic Energy Board.

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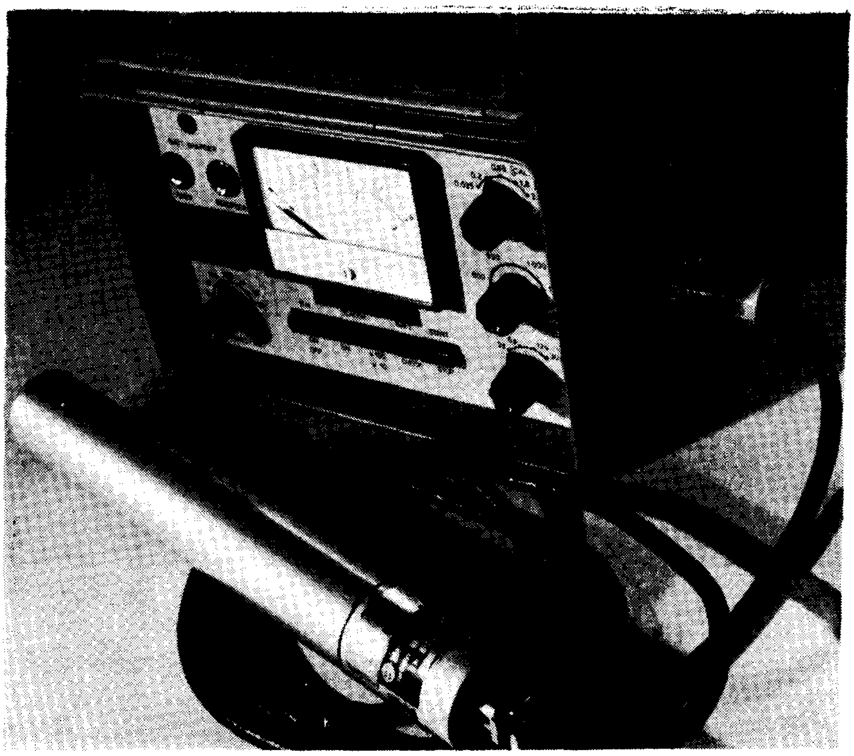

Fig. 3

Irrespective of the instrumentation, the operations involved are laborious and time consuming and have to be done by a trained observer. The instrument most commonly used is a scintillation counter and readings are usually taken systematically at pre-determined intervals along a compass bearing or surveyed line prior to the construction of radiometric contour map. When carrying out a detailed survey, readings must be taken at intervals of not less than 10 metres, and at a constant height above the ground. In practice the instrument is left switched on with a reading being noted at set intervals. Any anomalous readings occurring between the set intervals are also noted.

The Geology Division of the South African Atomic Energy Board, being well aware of the shortcomings and difficulties related to such a survey, has been instrumental in the development of a device attached to a cyclometer which considerably facilitates ground scintillometer surveys.

Because a number of organisations concerned with the prospecting for nuclear source materials have shown an interest in the device, the AEB has decided to publish details concerning its construction for the benefit of the mining industry as a whole. Construction is relatively simple and can be carried out at a cost of about R400 (excluding the cost of the scintillometer). For further details, enquiries should be directed to the Director, Instrumentation Division, Atomic Energy Board, Private Bag X256, Pretoria.

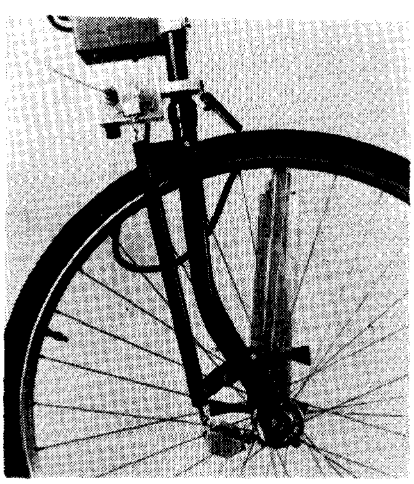

Fig. 2

INSTRUMENTATION

General

The instrumentation of the cyclometer as shown on Fig. 1 consists mainly of the following:

1. Scintillometer probe A with ratemeter B.
2. Recorder C.
3. Gearbox D.
4. Mechanical counter E.
5. Mechanical linkage and electrical cabling.

The scintillometer probe (A) detects the radiation from the ground. The signal is fed to the ratemeter (B) where it is processed and displayed on a meter. It is also transferred via a cable to the recorder (C). The paper drive of this recorder is operated by the cyclometer wheel via a flexible cable (F) running from the recorder to the gearbox (D) and then from gearbox and to drive shaft. The latter connection is clearly shown on Fig. 2. The gearbox makes it possible to vary the recording speeds in two steps (see knob underneath), so that one division ($\frac{1}{4}''$) on the paper represents either 10 m or 100 m. The recorder thus gives a direct reading of the radiation intensity against the distance. Additional to this there is also a mechanical counter (E) which counts 1 digit for every metre covered.

Tests carried out over a calibrated path of 500 metres gave a distance error of -4 per cent on the recording paper and $+2$ per cent on the mechanical counter.

The handlebar can be turned through 90° so that the cyclometer can be laid on its side and wrapped in a canvas bag during transport.

The weight of the cyclometer is about 10 kg.

Detailed description

1. *Scintillometer probe and ratemeter* (see Fig. 3)

The scintillometer used is a Berthold model SZ25/25D with a 25 X 25 mm NaI crystal. The anodised aluminium case also contains a photomultiplier tube and a pre-amplifier. The ratemeter/scaler is a model LB1821 also by Berthold with countrate ranges variable from 0-10 to 0-10 000 counts per second in 7 steps. The time constant is adjustable to 2, 5, 12 and 30 seconds. The

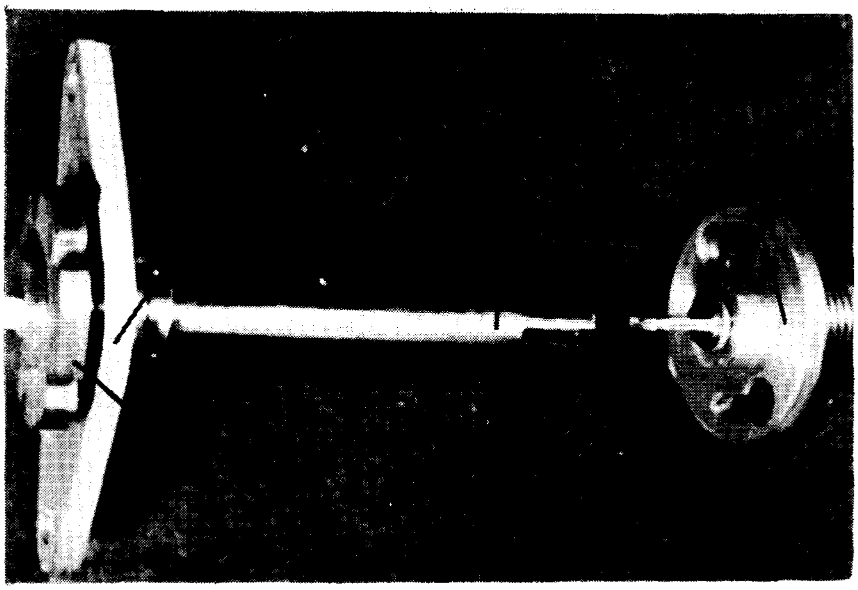

Fig. 4

mounting plate A on Fig. 5. The drive shaft assembly as shown on Fig. 4 was fitted after the original electric paper drive motor was removed. Part C on the same photo is the drive cable connection, and is mounted on the outside of the recorder case as can be seen on Fig. 1. It is fitted with slotted screw holes so that it can be easily removed, which is necessary whenever the recorder has to be opened for inspection or to be loaded with a new roll of chart paper. When the recorder is closed again, part C (Fig. 4) has to be remounted so that the flat shaft fits into the slot of shaft A.

Fig. 6 is a recording that was taken during a test with the aid of radioactive sources put on the ground. The peaks on the picture indicate

instrument also has a mechanical register with 6 digits.

The energy discriminating settings are as follows:

- 0,025 MeV; maximum sensitivity.
- 0,2 MeV; suppression of soft components, reduced scattered radiation level.
- 0,69 MeV; control adjustment with ^{137}Cs measurement of hard components (60C, 40K).
- 1,6 MeV; uranium+thorium 40K suppressed.
- 2,5 MeV; thorium.

The clearance between probe and ground can be adjusted to 50 cm.

2. *Recorder*

The recorder used is a miniature strip chart recorder model 88 made by Rustrak Instrument Co. Inc. The newer type model 288 is also suitable. It has a normal moving coil meter with a sensitivity of 1 mA f.s.d. The paper advancement is 3 inches/hour.

Instead of drawing a solid line, the recorder pointer is pressed against and released from the paper at a certain rate depending on the velocity of the paper advancement. Each time the pointer touches the paper it leaves a black spot. Originally there were some 150 spots per division, but this has been reduced to 47 in order to reduce friction. This was done by replacing a cam wheel which originally had 16 cams, with one having 5 cams.

This cam wheel is shown on Fig. 4 part B and it is located underneath

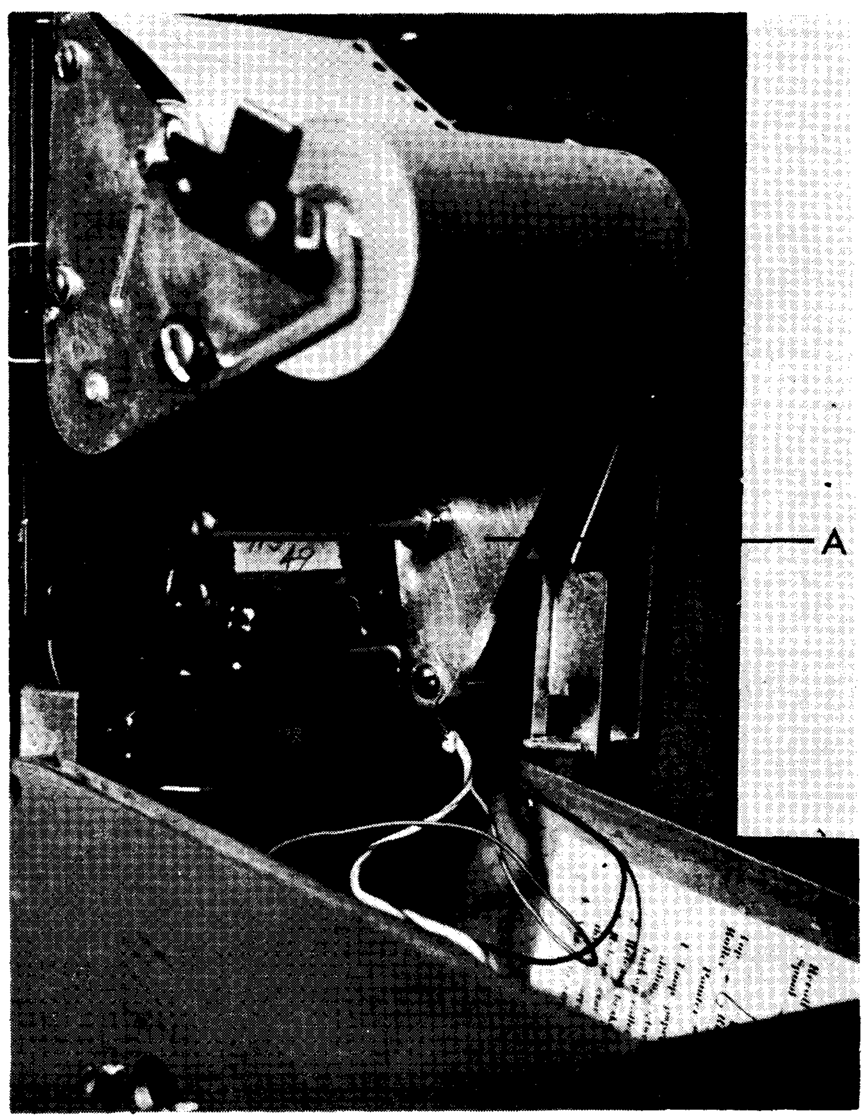

Fig. 5

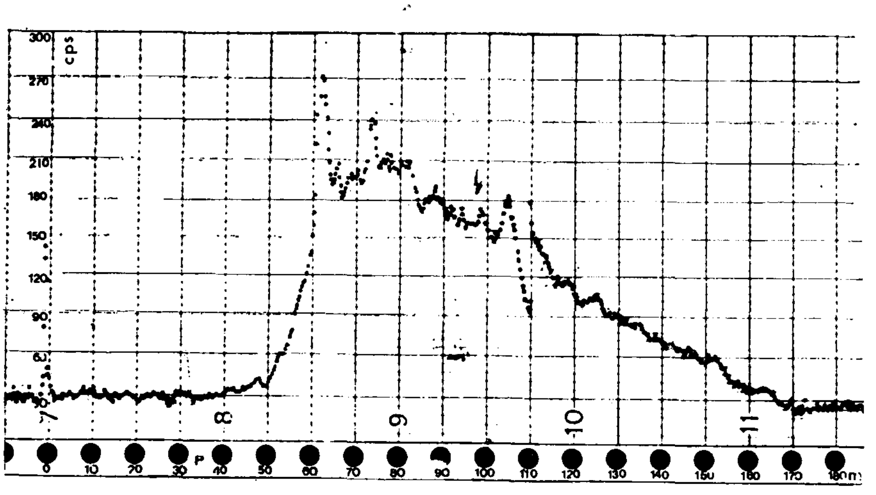

Fig. 6

that the cyclometer passed a source.

3. *Gearbox* (see Fig. 7)

The circumference of the cyclometer wheel is 2,25 m. The gear ratio from wheel to propeller shaft (see Fig. 2) is 8:15. So if the wheel makes one full revolution, the propeller shaft makes 15/8 revolutions. Over a distance of 10 m, this shaft will make $10/2{,}25 \times 15/8 = 8{,}35$ revolutions and 83,5 for 100 metre.

The chart paper was required to advance by 1 division (or $\frac{1}{4}''$) for every 10 or every 100 metres. One revolution of recorder shaft A on Fig. 4 gives 5 spots on the chart paper and there are 47 spots to one division, therefore this shaft has to make $47/5 = 9{,}4$ revolutions for a $\frac{1}{4}''$ paper advancement.

In the case of 1 division = 10 metres, the gear ratio has to be $9{,}4/8{,}35 = 1{,}12$ (stepping up) and for 1 division = 100 metre it will be 0,112 (stepping down). It seemed that the most practicable solution would be to make a gearbox with a fixed stepping-up ratio of 1,12 and a reduction unit which could be set at either 1 or 0,1.

The gearbox also had to provide the proper gear ratio for the mechanical counter, which has to count one digit for every metre covered by the cyclometer. The drive shaft coupled directly to the wheel gives 0,835 rotations for every metre so the gearbox has to increase this by a factor of $1/0{,}835 = 1{,}2$.

Fig. 8 shows in schematic form how the gearbox actually was made. The numbers stand for the number of teeth. Gear B is directly driven by the cyclometer wheel. Gear A and B together give a ratio of 1,2 as was required for the counter. Gears C and D give a stepping up ratio of 1,112 which is thought to be accurate enough for providing the 1,12 ratio for the recorder drive.

Gears E and F, and I and J give a reduction of 5 and 2 respectively, which makes a total of 10.

Clutch H can be slid from left to right or right to left. It is coupled to the same shaft as gear I by means of a spline. Gear I can rotate freely, all the other gears are fixed to their shafts. On the drawing, gear I is coupled to its shaft by means of clutch H, so that the ratio of rotation between wheel and recorder is 0,111 2.

In the other position H is coupled to G and E. The only function of disc G is to enlarge the area of E to facilitate the coupling process. Now the recorder is linked directly to D giving a ratio of 1,112 between wheel and recorder connection.

4. *Mechanical counter*

The purpose of this counter is to give a direct indication of the distance covered. The counter has four digits as can be seen on Fig. 9.

5. *Mechanical linkage and electrical cabling*

In order to convey the rotating movements from one part to another it was first thought that flexible shafts would be ideal for all three connections. However, the cable that was running from wheel to gearbox had to overcome the friction from both recorder and counter. It could not cope with this, and the cable twisted and acted like a spring so that the recorder movement became erratic. The cable was replaced by a solid shaft coupled to the wheel and the gearbox by means of universal joints and a rack and pinion. This is shown on Figs. 2 and 7.

The rack and pinion mounted directly on the wheel and the two

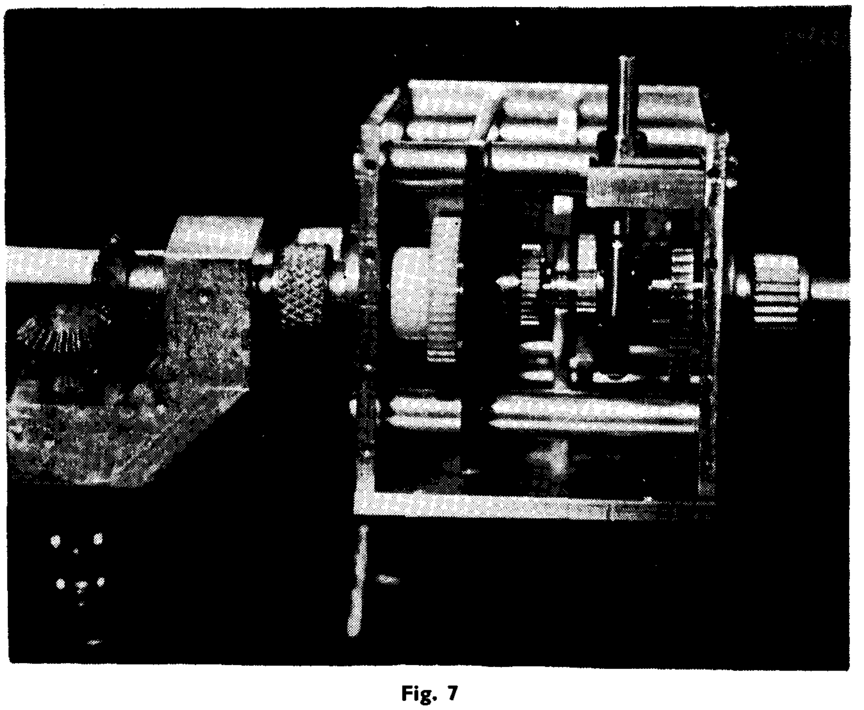

Fig. 7

flexible cables are from a normal bicycle speedometer. The cables were shortened to avoid twisting.

Apart from the normal cable connecting the scintillometer probe to the ratemeter, there is only one additional electrical cable required between ratemeter and recorder input. The recorder has a sensitivity of mA f.s.d. while the ratemeter gives a 10 V output at f.s.d. Therefore a 10 kΩ resistor had to be installed in the recorder.

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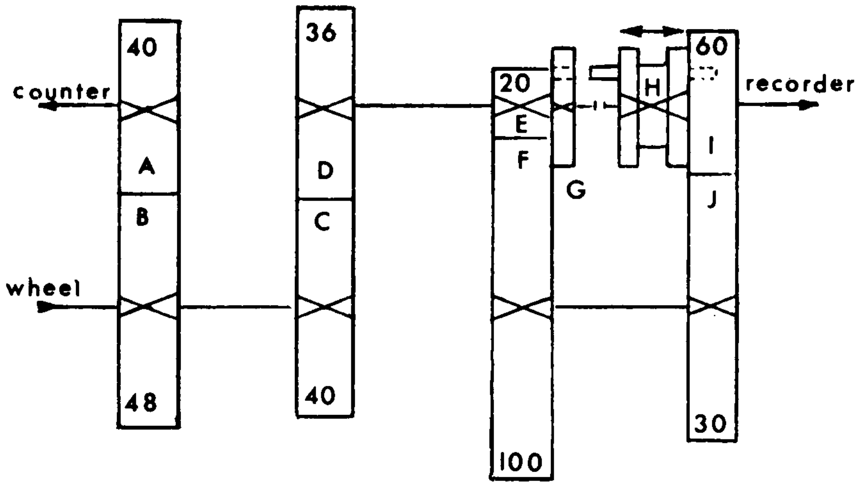

Fig. 8

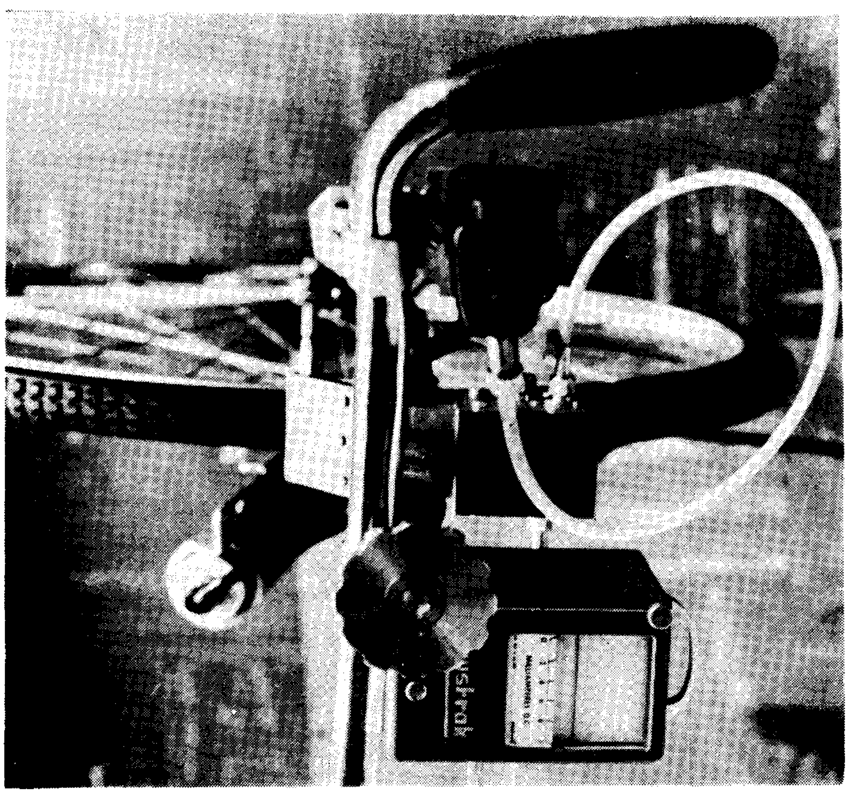

Fig. 9