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A SOLUTION TO THE NUMERICAL RECORDING OF A MERCURY BAROMETER

by

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Abstract

A device which uses a phototransistor, functions in accordance to a time signal and records numerically the readings of a mercury barometer has been developed. With this device it is possible to establish the position of the mercury surface to an accuracy of 0.01 mm.

1. *Introduction*

For the purpose of registering cosmic rays a neutron monitor, 9-NM-64, has been constructed at Oulu University in the department of physics. The register output must be continually corrected to a constant pressure. To accord with the requirements of the IQSY the air pressure for a one-hour registration period should be obtained by averaging the pressure in 5-minute intervals with an accuracy of 0.1 mm Hg. Reading the pressure with an ordinary mercury barometer is difficult and it is an overpowering job when performed with this frequency. A device for a Lambrecht-604 mercury barometer, now in use, which meets these requirements has been developed.

2. *Construction and operation*

The system is shown in Fig. 1. The height of the mercury is determined by the lamp-phototransistor system A, which is connected by a toothed

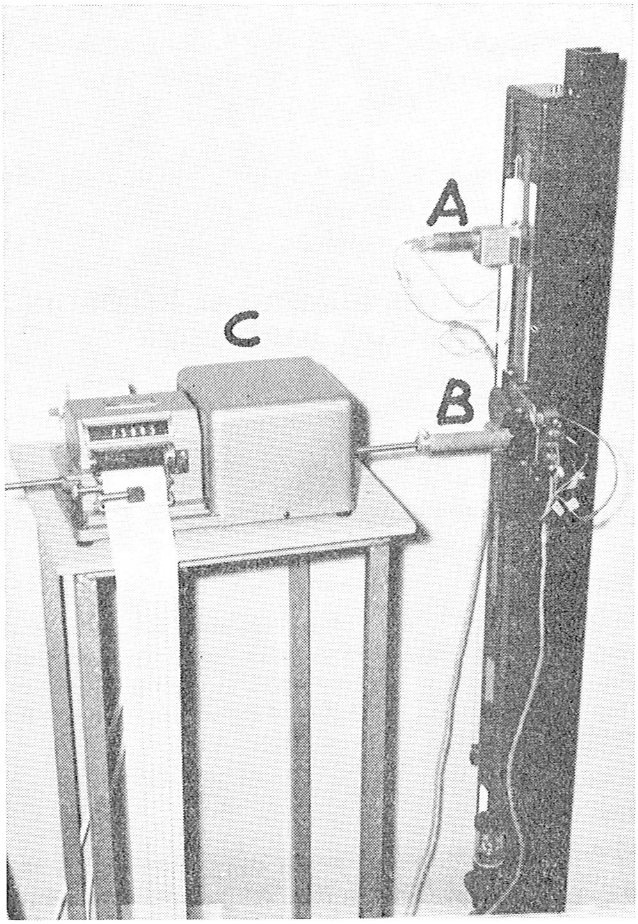

Fig. 1. Photograph showing the registration system.

rod and wheel to the electric motor *B* and then to a tachometer *C*. The chance in height of the comparison surface within the mercury container due to a change in pressure, is compensated by a change in the gear ratio. The Irion & Vosseler U 272 Tachometer has been used as the rotation counter. Its readings can be printed out using an external signal without zeroing the counter.

The operation of the device is shown in Fig. 2. A phototransistor circuit directs the relay R_1 through a Schmidt triggering circuit V_1. The relay is on when the phototransistor receives enough light and off

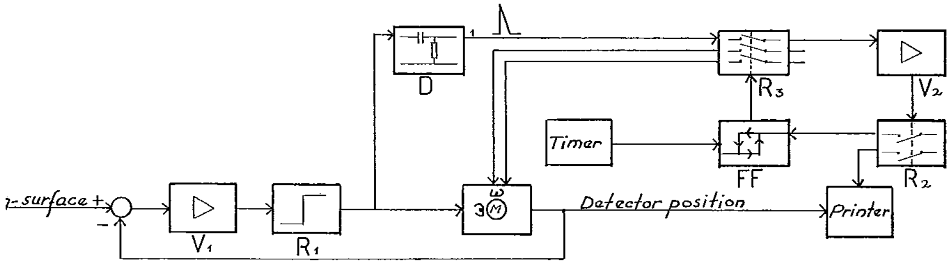

Fig. 2. Block diagram showing the operation of the entire system. Arrows indicate the direction of information.

when the light is not sufficient. A time signal, or a push button contact, directs through a flip-flop circuit FF the relay R_3 which directs the current to the motor M and makes possible the print out command to the relay R_2 by the amplifier V_2. Depending on whether the relay R_1 is on or off, the motor starts to rotate the pressure recorder downwards or upwards. On the first pull contact of the relay R_1 a pulse is received in the differentation circuit D which directs relay R_2 through the monostable multivibrator amplifier V_2, to give a printout command to the tachometer and also returns FF to its initial position while the relay R_3 is off. Then the motor stops and the printout command to the tachometer is cut off. The system is now ready for the next pressure reading.

The movements of the barometric recorder from the time of the reception of the time signal to the moment of print-out are

A. The pressure rises

1. The pressure has risen so much that the relay R_1 is off. The motor starts to raise the recorder. When R_1 pulls, the printout takes place.
2. The pressure has risen so little that relay R_1 is on. The motor starts to carry the pressure recorder down until the relay R_1 is off when the direction of the motor rotation is changed and the pressure recorder starts to rise. When the relay R_1 pulls, the print-out occurs.

B. The pressure falls

The relay R_1 is on so that the operation is the same as in the case 2 above.

Hence the printout occurs always while the pressure recorder is moving from the bottom upwards and while the relay R_1 pulls.

When putting the recording device into use, the system must first be allowed to seek its print-out position without the tachometer, the tachometer must be rotated to the reading corresponding to the pressure which can be obtained from a barometer in the normal way, and then the tachometer is placed into the transmitting system. After this the pressure can be registered using a time signal or a push button.

3. *Results of measurements*

In order to establish the degree of accuracy with which the height of the surface is determined the barometer was arrested or locked and the device was allowed to register from Nov. 17, 1965 at 15.00 to Nov. 18, 1965 at 09.00 using 5-minute time intervals. Over the period of one hour the average of the deviations of the individual recordings from the average of the entire registration period were in the hundredth part of mm:

Time	16	17	18	19	20	21	22	23	24	1	2	3	4	5	6	7	8	9
Dev.	1,0	0,1	0,1	−1,1	−0,9	−1,7	−2,9	−3,1	−3,4	−5,2	−1,7	0,3	−1,0	1,1	3,6	4,0	4,8	6,0

The mean deviation of the individual recordings from the average value of the whole period is 0.019 mm. From the thermograph it was established that the temperature had dropped about 0.3°C during the night and had risen a corresponding amount in the morning hours. It is evident that the differences to the most part results from changes in temperature. We obtain a better picture of the accuracy with the aid of the average of the absolute value of the deviations of the individual registrations from the average of the 1-hr period to which they belong:

Time	16	17	18	19	20	21	22	23	24	1	2	3	4	5	6	7	8	9
Dev.	0,7	1,0	0,4	0,9	0,5	0,4	0,6	0,9	1,2	0,8	2,0	1,1	0,9	1,3	1,2	1,3	1,3	1,1

The deviation of the individual registration from the hourly average to which it belongs is on the average 0.0098 mm. In a thermally well-regulated space, it is therewhore possible to reach an accuracy of 0.01 mm.

In order to establish the accuracy with which the barometer can follow the pressure changes, the results of the Fuess 11 A/9 mercury barometer situated at a distance of 15 km at the airport at Oulunsalo have been used. Fig. 3 shows the registrations from both devices Oct. 20, 1965 at 20.00 to Oct. 28, 1965 at 08.00. At this time the pressure decrease which occurs is smooth and large being well suited for comparison.

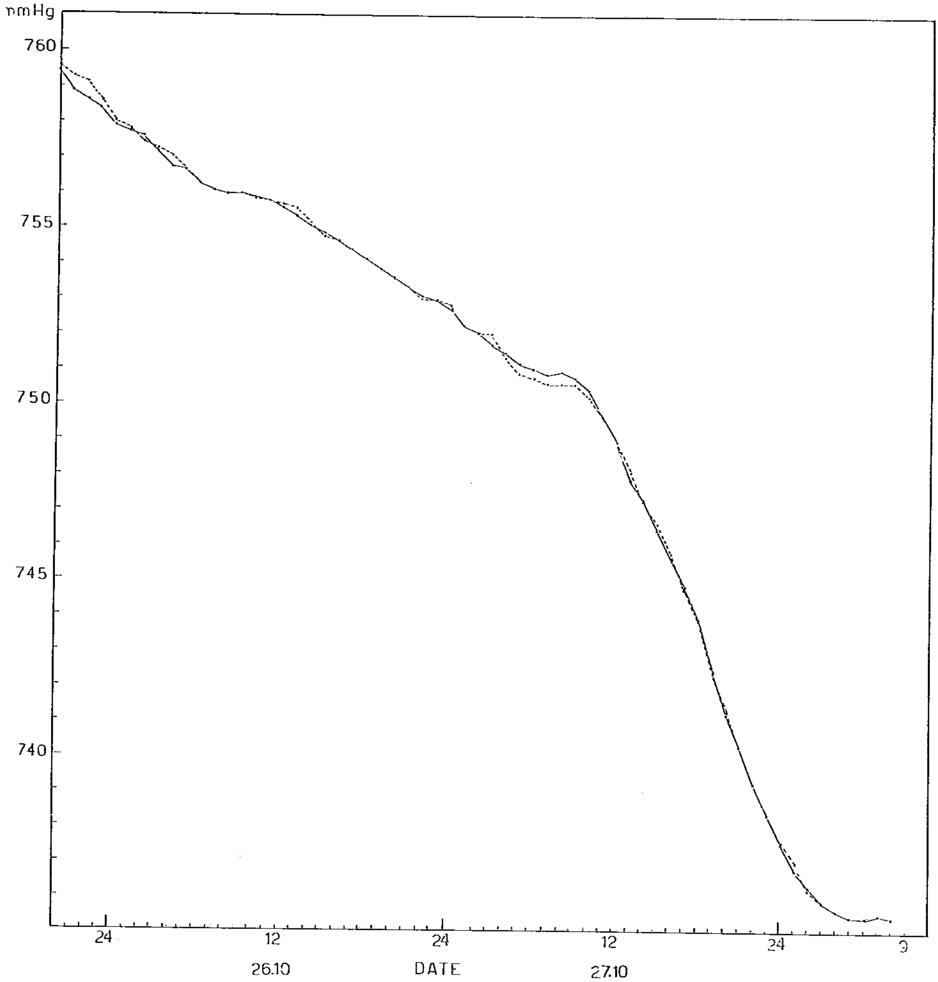

Fig. 3. Comparison of the readings of our barometer (full line) located at Oulu and the barometer located at the Oulunsalo airport (dotted line).

The average value of the individual values of the pressure differences is 0.12 mm Hg. This results, in large part, from the differences which appear in the 25th and 27th days. If Oct. 25, 20.00—23.00 and Oct. 27, 01.00—11.00 are omitted from the evaluation (since apparently a local pressure gradient has occurred) 0.058 mm Hg is obtained for the average value of the individual values of the pressure differences. For the average value of the pressure differences we obtain 0.02 mm Hg. From these values as well as from the curves in Fig. 3 we can conclude that our recording device follows the pressure at least with the accuracy of the airport barometer, i.e., 0.1 mm Hg.

4. *Discussion*

Our barometer is in the room in which the temperature is stabilized to an accuracy of ± 0.5°C. Naturally it would be possible to stabilize the temperature of the barometer even better but since an accuracy of 0.1 mm Hg is sufficient and we do not have available a sufficiently good stationary comparison barometer we have not done this to the present. Evidently the accuracy in measuring the pressure is the same as the accuracy in locating the position of the surface when the temperature remains constant.

The curved surface of the mercury column affects the accuracy of the determination of the location of the surface. The surface acts as a curved mirror spreading out the light which impinges on it and only the light transmitted over would reach the light sensitive part of the phototransistor. By improving the optics it would be possible to improve, when necessary, the accuracy of determining the surface.

This device may be used also with other measuring instruments using mercury such as for example a thermometer. For the present, however, no experiments have been performed with these.

Acknowledgements: The author wishes to thank Mr. A. Juntunen, who has successfully participated in constructing the apparatus and also Mr. P. Tanskanen, Phil.Lic., for valuable discussions. I am also gratefull to Prof. Charles O. Ahonen for his translation of the manuscript. As being a technical part of the work on a neutron monitor 9-NM-64 the apparatus has been built under a program sponsored by the Finnish Atomic energy Commission and the National Research Council for Sciences.