EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

EP INTERNAL REPORT No. 77-3
10.2.77.

THE AUTOMATIC STABILISATION OF GAS AMPLIFICATION IN LINEAR MULTI-WIRE PROPORTIONAL CHAMBERS

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1. INTRODUCTION

Proprotional chambers are traditionally used in High Energy physics experiments to provide information about the position of the passing particles. However, there is an increasing number of experiments where also particle ionisation losses (plus transition radiation) released in the gas of the chamber are required [1,2,3].

The proportionality constant between the ionisation in the chamber and output pulse is a product of the gas gain in the chamber and the electrical gain of all amplifier stages. While the gain stability of the amplifiers does not represent a problem, the gas gain of the chamber drifts naturally, mainly due to the following reasons:

1) Atmospheric pressure variation $\frac{\Delta A}{A} = -7 \frac{\Delta p}{p}$
2) Temperature variation
3) Variation of the gas mixture (80% Xe, 20% Co^2) and impurities during long term periods when the gas circulates through purifiers.

Since it is not practical to affect any of these parameters the method chosen was to vary the EHT voltage on the chamber to keep the gas gain constant.

2. SET UP

To monitor and stabilise the gas gain of the main chambers, a small monitor chamber of similar characteristics was put in series with the gas system. This chamber was mounted at the same height as the main chambers so that the gas gain in all chambers would vary in a similar manner. The monitor chamber was used to detect the 6.4 keV peak of a Co59 source and it is on this peak that the stability was measured and automatic correction made.

3. PRINCIPLE

The principle of the stabiliser is to "lock" the position of the Co59 peak between two chosen points or channels, one on the upper and

one on the lower flanks of the peak, both situated about half height. Counts falling into these channels are counted in a forward/backward scaler, one channel adding counts the other subtracting counts from the scaler. If the peak remains perfectly positioned then the net counts in the scaler would remain unchanged. However, should the peak displace, the scaler content will change. This change of content is used via a digital to analog converter to alter the control voltage of the EHT power unit feeding the chambers thus redressing the peak to its original position.

4. APPARATUS

The spectrum of the Co^{59} source was accumulated in a small 256 channel pulse height analyser, type CERN N-7308[4]. This analyser has several features which are convenient for use in this stabiliser application. The two points on the peak can be located by using the numerical channel number and content display. The digital channel number is available on a front panel connector for use in the comparator of the stabiliser unit.

The stabiliser unit consists of a dual three decade (BCD) comparator and a 20 bit binary scaler; the most significant 8 bits of the scaler being connected to a digital to analog converter. The remaining 12 bits of the scaler may be switched in blocks of four bits and used as a pre-scaler if desired.

Two sets of wheel switches are pre-loaded with the chosen channel numbers on the peak. This information is compared to the analyser channel number information at the end of each count analysis cycle, one comparator adding counts to the scaler the other subtracting counts. A two position front panel switch "Lock and Stabilise" provides the remaining control. Position "Lock" blocks the scaler in a non counting position with the most significant bit loaded to "1" thus setting the content of the scaler to half its maximum value. "Lock" position is used to locate the peak on the analyser and chose the two reference channels on the peak. "Stabilise" position permits the system to function as a closed loop.

Should the scaler overflow in either direction the system returns to "Lock" position and an audible alarm sounds.

5. ANALYSIS

Let us write for the overall gain change ΔG_{Tot} in the chamber

(1) $\Delta G_{ToT} = \Delta G_{H.T.} + \Delta G_{Gas}$

where $\Delta G_{H.T.}$ is the part of the gain change due to the H.T. changes and the ΔG_{Gas} includes all other possible changes.

If we limit ourselves to the linear approximation we can write

(2) $\Delta G_{H.T.} = \alpha . \Delta V$ where α is a set-up constant which can be easily measured.

As described in the text stabilising action is done by changing the H.T. proportionally to the time integral of the total gain variation (counting the difference between two channels at the same distance up and down from the peak position).

so

$$(3) \quad \Delta V = -\beta \int_{to}^{t} \Delta G_{Tot} dt \qquad \beta > 0$$

where we have the freedom to choose the β value, differentiating (3) and using (2) and (1) we can easily obtain

$$\Delta G'_{H.T.} + \alpha . \beta \Delta G_{H.T.} = - \alpha \beta \Delta G_{Gas}$$

To take an example let us assume that ΔG_{Gas} is changing harmonically with the period corresponding to the meteological scale ($\simeq$ day)

$$\Delta G_{Gas} = \Delta G^{(o)}_{Gas} \times e^{i\omega t}$$

solving for

$$\Delta G_{H.T.} = \Delta G^{(o)}_{H.T.} \times e^{i\omega t} + o^{(t)} \text{ where}$$

$$\Delta G^{o}_{H.T.} = \frac{-\alpha\beta \Delta G^{(o)}_{Gas}}{\alpha\beta + i\omega}$$

or for the overall gas gain we can write

$$\Delta G_{Tot} = \Delta G_{H.T.} + \Delta G_{Gas} = \frac{i\omega}{\alpha\beta + i\omega} \Delta_{Gas}$$

FIG. 1

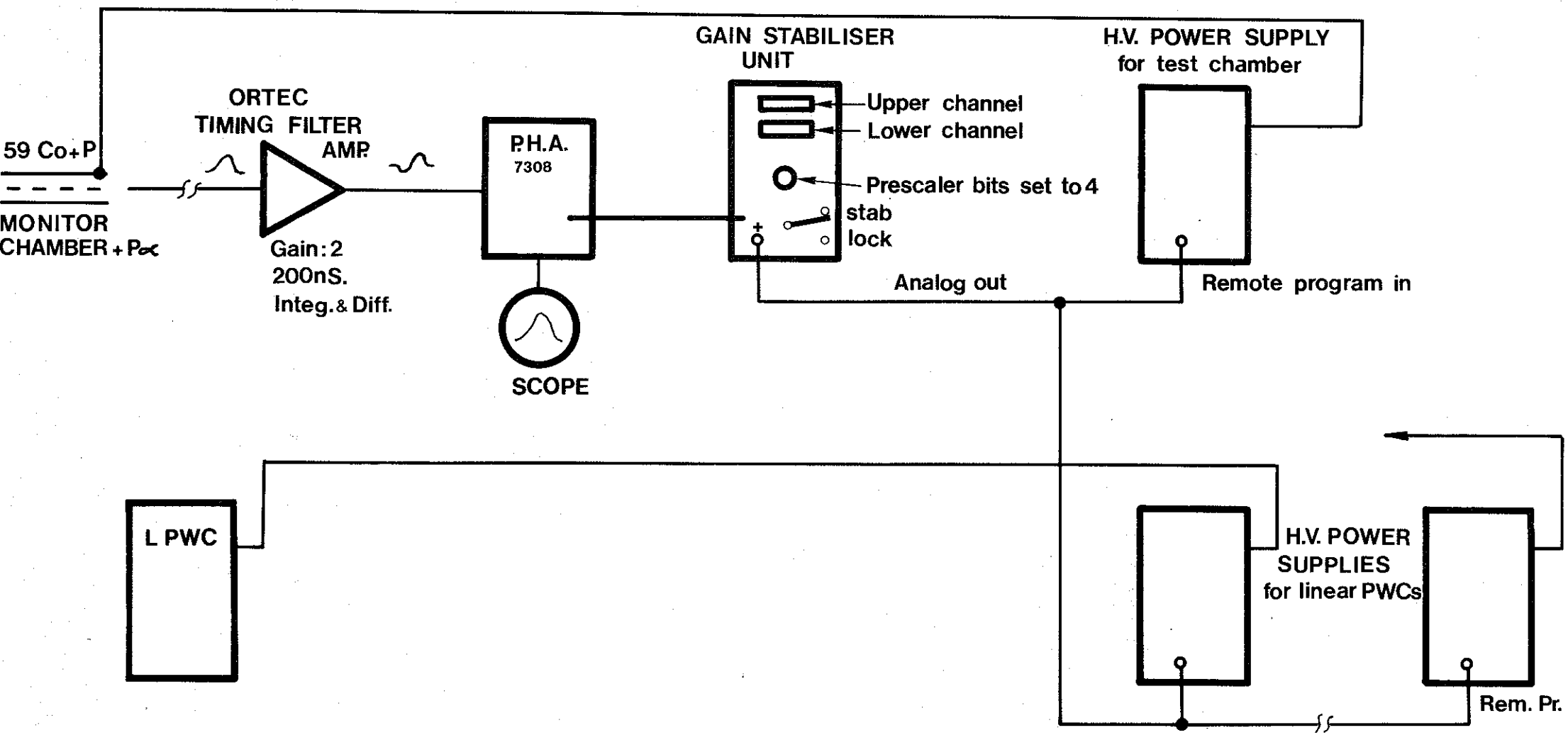
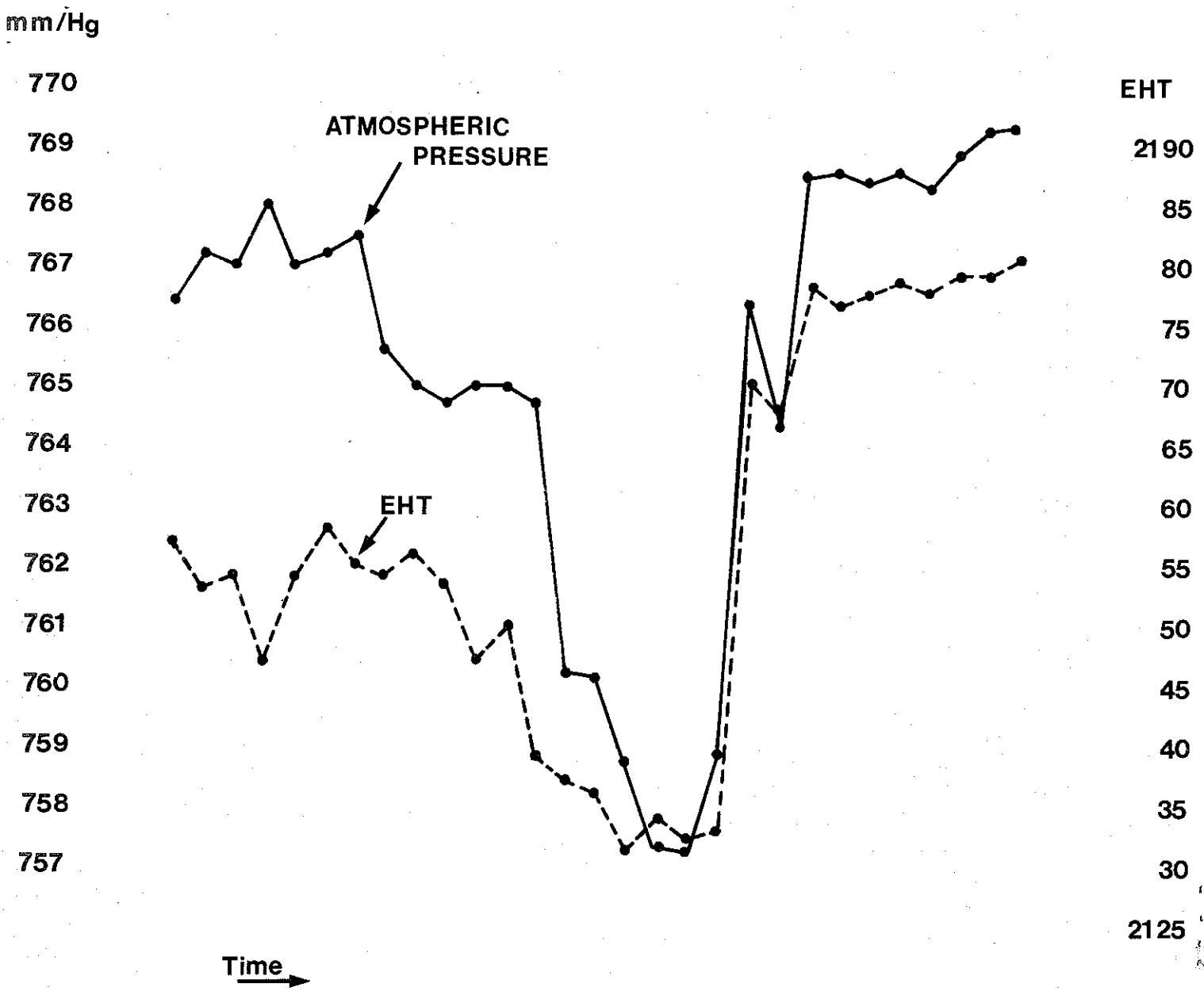

GAIN STABILISER
UNIT
H.V. POWER SUPPLY
for test chamber
ORTEC
TIMING FILTER
AMP.
59 Co+P
P.H.A.
7308
Upper channel
Lower channel
Prescaler bits set to 4
stab
lock
MONITOR
CHAMBER + Pα
Gain: 2
200nS.
Integ. & Diff.
Analog out
Remote program in
SCOPE
L PWC
H.V. POWER
SUPPLIES
for linear PWCs
Rem. Pr.

FIG. 2



MONTH OF MAY 1976