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भारत सरकार
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ATOMIC ENERGY COMMISSION

A NOVEL METHOD OF SPECTRUM STABILIZATION

by

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ABSTRACT

A new type of spectrum stabilizer for a scinitillation spectrometer is described. A pulsed light source DM 160 is used to introduce an artificial peak in the spectrum at a convenient energy. The centroid of pulse spectrum corresponding to artificial peak is compared with that of suitable reference pulses obtained from the DM 160 driver circuit. Any drift in artificial peak produces a d.c. voltage at the output of centroid comparator and this voltage is used to control the gain of variable gain amplifier to counter the drift. With suitable adjustment the effect of any variation in pulse height of DM 160 driving pulse can be compensated so that the spectrometer gain is independent of any variation, drift etc. in the height of pulse driving DM 160 tube. This circuit is simple and gives improved performance compared to 2 channel method of obtaining the control voltage for variable gain amplifier.

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1. INTRODUCTION

Many types of spectrum stabilizers have been reported in literature[1-9]. Most of these make use of a peak (in the spectrum or introduced by mechanical chopper or external light sources). The counting rate on two sides of this peak is measured with a single channel or a two channel analyzer. These counting rates are compared with count ratemeters or flip-flop etc. and a D.C. signal is derived which changes E.H.T. of photomultiplier tube or the gain of preamplifier, or the there-shold and slope of the analyzer, suitably, to counter the shift in peak position. This ensures that the counting rate in the two channels remains equal. Such a system is subject to drift due to variation in the threshold and width of the two channels. Also the stabilizeing action introduces a noise in the controlling voltage and thus the width of a peak increases as discussed by Wilkinson[1] and Ward[2].

The above mentioned method does not make full use of information contained in the spectrum of artificial peak to determine its position (or gain of the spectrometer). A statistically better method is to find the centroid of this spectrum. This gives a smaller error as compared to 2 ch method of finding the peak position.

In this stabilizer external light source has been used. With this source the energy of the artificial peak and counting rate can be varied as desired.

2. STABILITY REQUIREMENTS

This stabilizer is to be used with single channel ray gamma spectrometer in this lab. The spectrometer gain varies by about 5% over a day. To get a stability of the order of 0.1% stabilization factor of 50 is required. The extra variance introduced due to stabilizing actions should also be of the same order for optimum stability. As the gain of a photomultiplier tube changes with counting rate and the time constants for the gain to settle to new level range from few minutes to hours[12], therefore the time constant for spectrometer stabilizer should be at least an order of magnitude smaller, so that the gain does not change with counting rate. Thus the stabilization time constant should be few seconds.

3. DESCRIPTION OF THE CIRCUIT

A block diagram of the set up is shown in Fig.1. A small flash tube DM 160 is used as the light source. It is pulsed with pulses (height adjustable between 36 to 48 V) with a decay time of 1 μ sec. The rise time of these pulses is less than 0.1 μ sec. The light from flash tube passes through a slit on to a hole in the light guide covering. The slit width can be adjusted to get the peak at desired energy. The signal due to this flash of light is amplified by the photomultiplier tube, preamplifier, variable gain amplifier and main amplifier. The output pulses from the main amplifier are applied to two linerar gates 1 and 2. Gate no.1 is normally blocked while gate no.2 allows the pulses due to sample radiation source to pass through for analysis.

3.1 DM 160 Driver Circuit

As shown in Fig.2 consists of an assymmetrical multivibrator running at 1 Kips. The output pulses are shaped to get a fast rising pulses of height equal to the supply voltage. This pulse is differentiated with 1μ sec. time constant. Two attenuated outputs one +ve and another -ve are also provided by this circuit. The +ve pulse trigger the univibrator. The width of output pulses from univiabrator is 7μ sec. Two outputs from the univibrator are applied to two gates such that the gate no.1 allows pulses to pass through while the gate no.2 is blocked for a duration of 7μ sec. The effect of this is that the pulses corresponding to artificial peak go to centroid comparator only and not to the analyzer.

3.2 Centroid Comparator

Positive pulses from gate no.1 and -ve pulses from DM 160 drive circuit, are both stretched with 1m sec. decay time and applied to the in put of the integrator through 10 megohm resistance. The integrator comprises of BFW 11 a FET transistor, two SG 322 transistors and CIL 603 transistor as emitter follower. A two microfarad polyster capacitor is used as the integrating capacitor. D.C. output voltage from this integrator after suitable off set is applied to variable gain amplifier to control its gain. The variable gain amplifier in similar to one described by Marz[10] while. The liner gates are based on the design of Elad[11].

4. ADJUSTMENT AND OPERATION

With switch at 'OUT' position i.e. with stabilizer inoperative; slit width is adjusted such that the output from gate No.1 is approximately of the same height as the height of -ve output from DM 160 driver circuit. Then this switch is put at 'IN' position. The stabilizer takes over and gain reaches its equilibrium value in about one minute. The control voltage applied to the variable gain amplifier is monitored with a voltmeter.

Now if the height of driving pulse Vd is varied by adjusting potentometer P1, it is found that the height of output pulses from gate No.1, Vo, varies as 3/2 power of Vd. Thus same relation holds between

(V-) negative output from driving circuit and Vo. If there occurs variation of X% in V- and it causes a variation of X% in Vo pulse height; then such a variation will be automatically compensated, thus making the system gain independent of any variations in the height of pulse DM 160 tube. This is achieved by passing the negative pulse through a baised emitter follower and adjusting this bais with P_2 so that output Vo varies linearly with output V- for a small range about the operating point.

5. PERFORMANCE

The gain of this stabilizer is about 50. This gain is adequate to take care of gain variation which are of the order 5% -7%.

The extra variance introduced by the stabilizer action is quiet small in fact so small that it is not detectable with the usual method of measuring the half width of a peak in spectrum with and without stabilizer. An attempt was made to measure this broadening by introducing pulses at the input of the variable gain amplifier with another pulse generator. The width of this peak was measured with SC 603 at a window width of 0.02 volts. This width was 1.2% with and without the stabilizer within the error of width determination of ± 0.1%. The stabilizing time constant is about 5 seconds. The maximum pulse height variations during a day is within 0.4%. Thus the performance of this stabilizer is quite satisfactory. This performance is obtained by keeping phototube assembly, DM 160 driver circuit and controid comperator circuit inside a constant temperature enclosure. An improved performance is likely to be obtained if room temperature is held constant and condant voltage transformer is used for keeping the supply voltage constant.

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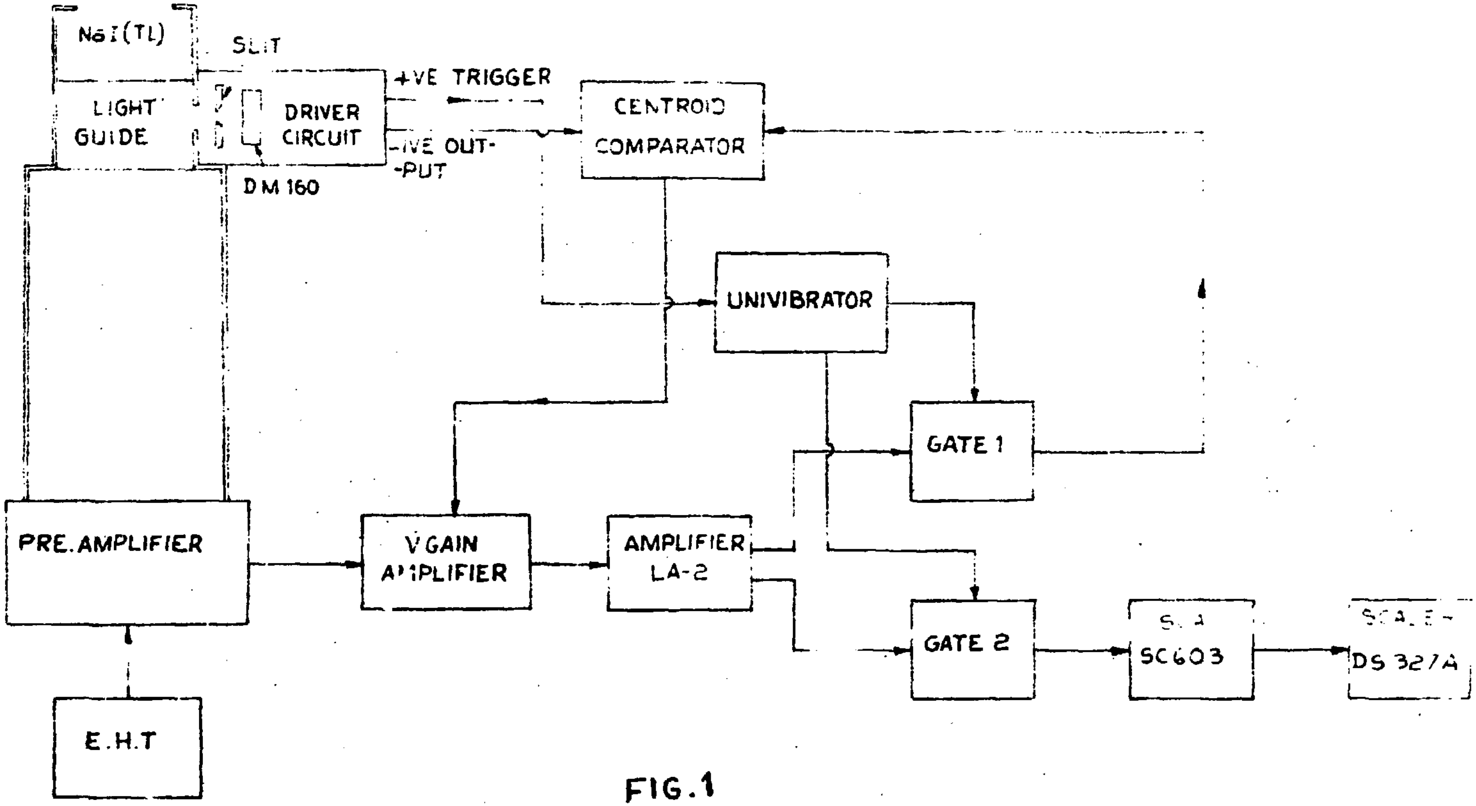

FIG.1

BLOCK DIAGRAM OF STABILIZER CIRCUIT

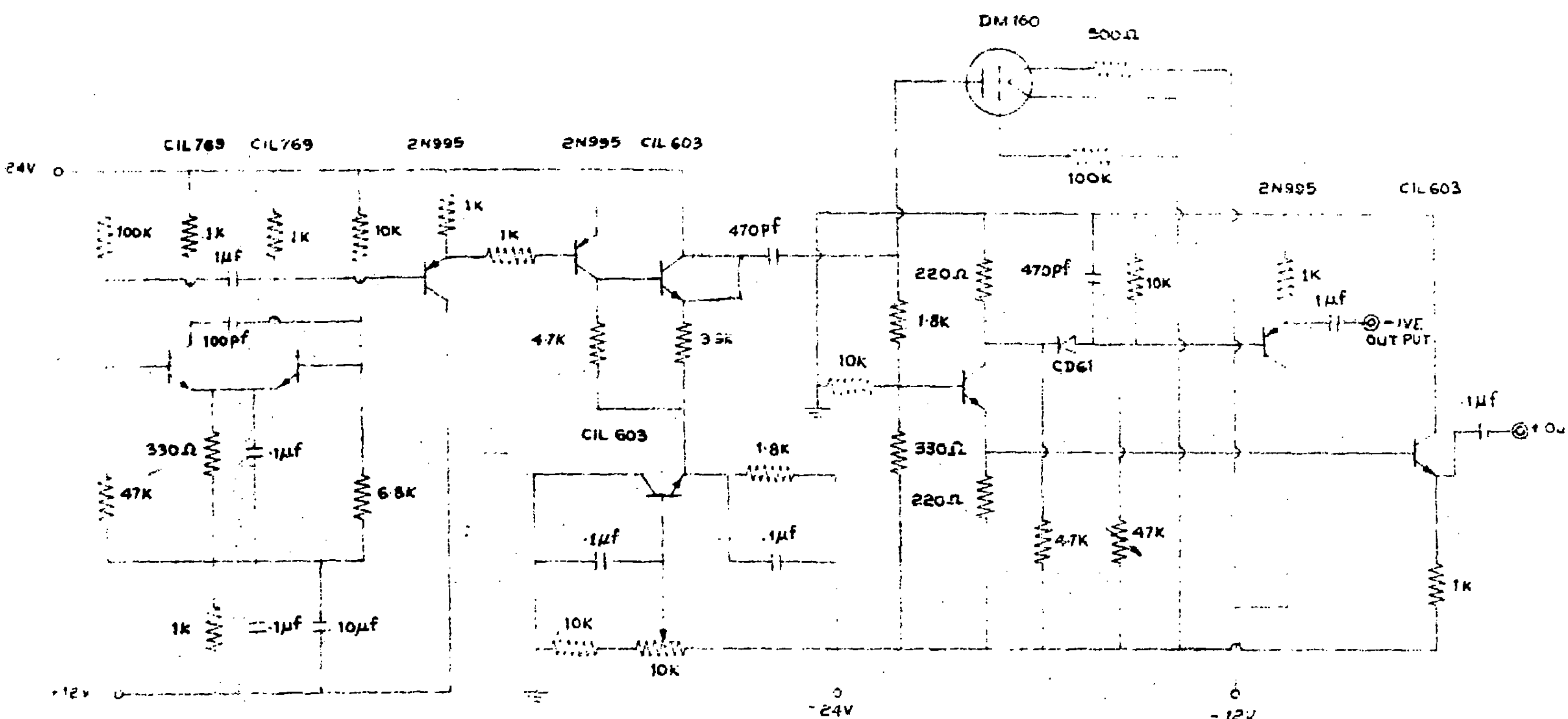

FIG. 2

DM 160 DRIVER CIRCUIT DIAGRAM

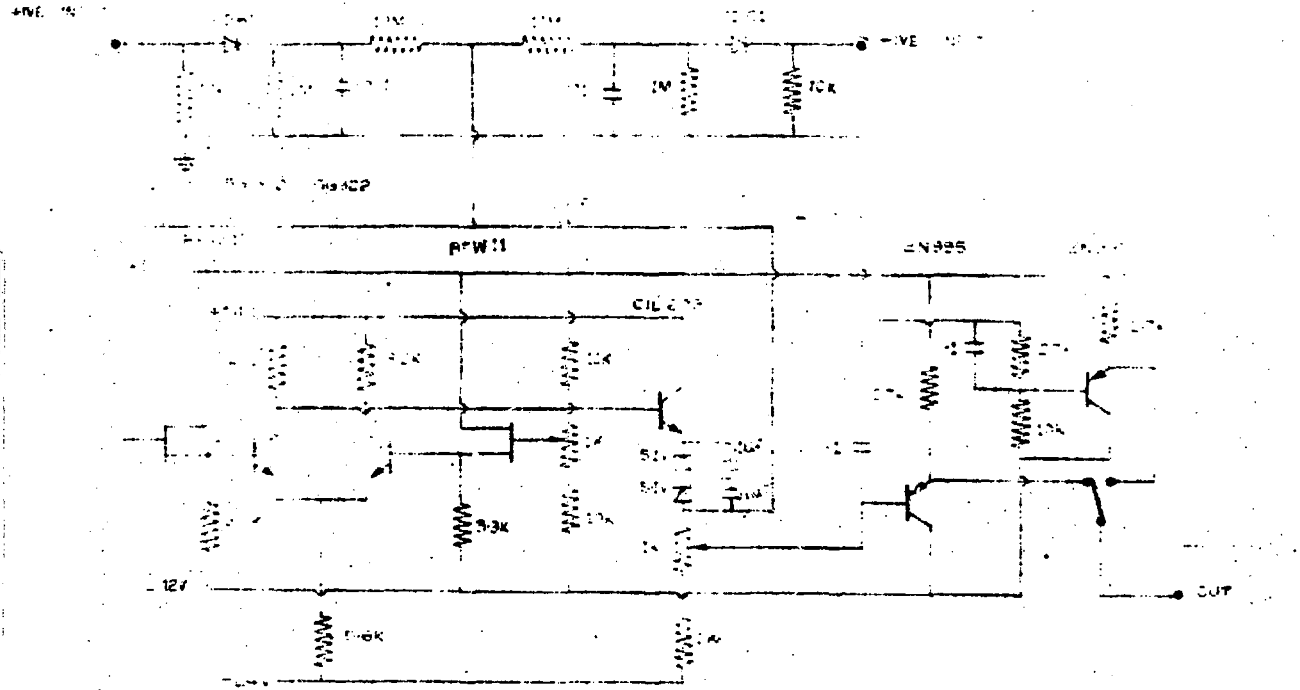

FIG. 3

CENTROID COMPARATOR CIRCUIT DIAGRAM