Title
A NEW COUNTING RATE RECORDER

Author
Anger, H.O.

Publication Date
1950-08-30

UNIVERSITY OF CALIFORNIA

Radiation Laboratory

BERKELEY, CALIFORNIA

COPY 2

UNCLASSIFIED

UCRL 885
Unclassified Distribution

UNIVERSITY OF CALIFORNIA

Radiation Laboratory

Contract No. W-7405-eng-48

A NEW COUNTING RATE RECORDER

H. O. Anger

August 30, 1950

Berkeley, California

INSTALLATION:	No. of Copies
Argonne National Laboratory	8
Armed Forces Special Weapons Project	1
Atomic Energy Commission, Washington	2
Battelle Memorial Institute	1
Brush Beryllium Company	1
Brookhaven National Laboratory	4
Bureau of Medicine and Surgery	1
Bureau of Ships	1
Carbide and Carbon Chemicals Division (K-25 Plant)	4
Carbide and Carbon Chemicals Division (Y-12 Plant)	4
Chicago Operations Office	1
Columbia University (J. R. Dunning)	1
Columbia University (G. Failla)	1
Dow Chemical Company	1
H. K. Ferguson Company	1
General Electric, Richland	3
Harshaw Chemical Corporation	1
Idaho Operations Office	1
Iowa State College	2
Kansas City Operations Branch	1
Kellex Corporation	2
Knolls Atomic Power Laboratory	4
Los Alamos Scientific Laboratory	3
Mallinckrodt Chemical Works	1
Massachusetts Institute of Technology (A. Gaudin)	1
Massachusetts Institute of Technology (A. R. Kaufmann)	1
Mound Laboratory	3
National Advisory Committee for Aeronautics	1
National Bureau of Standards	3
Naval Radiological Defense Laboratory	2
New Brunswick Laboratory	1
New York Operations Office	3
North American Aviation, Inc.	1
Oak Ridge National Laboratory	8
Patent Branch, Washington	1
Rand Corporation	1
Sandia Corporation	1
Santa Fe Operations Office	2
Sylvania Electric Products, Inc.	1
Technical Information Division (Oak Ridge)	15
USAF, Air Surgeon (Lt. Col. R. H. Blount)	1
USAF, Director of Armament (Captain C. I. Browne)	1
USAF, Director of Research and Development (Col. R. J. Mason, Fred W. Bruner)	2
USAF, Eglin Air Force Base (Major A. C. Field)	1
USAF, Kirtland Air Force Base (Col. Marcus F. Cooper)	1
USAF, Maxwell Air Force Base (Col. F. N. Moyers)	1
USAF, NEPA Office	2
USAF, Office of Atomic Energy (Col. H. C. Donelly, A. A. Fickel)	2
USAF, Offutt Air Force Base (Col. H. R. Sullivan, Jr.)	1
USAF, Wright-Patterson Air Force Base (Rodney Nudenberg)	1

INSTALLATION:	No. of Copies
U. S. Army, Atomic Energy Branch (Lt. Col. A. W. Betts)	1
U. S. Army, Army Field Forces (Captain James Kerr)	1
U. S. Army, Commanding General, Chemical Corps Technical Command (Col. John A. MacLaughlin thru Mrs. Georgia S. Benjamin)	1
U. S. Army, Chief of Ordnance (Lt. Col. A. R. Del Campo)	1
U. S. Army, Commanding Officer, Watertown Arsenal (Col. C. H. Deitrick)	1
U. S. Army, Director of Operations Research (Dr. Ellis Johnson)	1
U. S. Army, Office of Engineers (Allen O'Leary)	1
U. S. Army, Office of the Chief Signal Officer (Curtis T. Clayton thru Maj. George C. Hunt)	1
U. S. Army, Office of the Surgeon General (Col. W. S. Stone)	1
U. S. Geological Survey (T. B. Nolan)	2
~~USAF, Director of Plans and Operations (Col. R. L. Applegate)~~	~~1~~
U. S. Public Health Service	1
University of California at Los Angeles	1
University of California Radiation Laboratory	5
University of Rochester	2
University of Washington	1
Western Reserve University	2
Westinghouse Electric Company	4
Naval Medical Research Institute	1
California Institute of Technology (R. F. Bacher)	1
TOTAL	138

Information Division
Radiation Laboratory
University of California
Berkeley, California

A NEW COUNTING RATE RECORDER

H. O. Anger

Radiation Laboratory and Division of Medical Physics
University of California, Berkeley, California

August 30, 1950

Introduction

There are many applications of G-M and scintillation counting where a suitable recording counting rate meter can be very useful. When doing certain *in vivo* biological tracer experiments, for instance, the counting rate from one or more counters must be followed closely for hours, resulting in a quantity of data which requires much routine labor to record, compute, and plot by hand.

Most of the counting rate meters used in the past have been of a particular type in which the influence of any given count on the indicating meter decreases with time at an exponential rate after the occurrence of the count.[1,2] An instrument of this type has the disadvantage that when a large change in the counting rate occurs, a relatively long time is necessary for it to reach equilibrium and thus indicate the new counting rate correctly. A special statistical theory is necessary to evaluate the statistical errors and transient response of an instrument of this type.[3]

A new type of recording counting rate meter which has the following advantages is described in this paper. First, the recorder plots a series of points, each point of which represents the arithmetic mean of the counting rate during a given fixed interval of time. The regular statistical theory is then valid. In addition, the instrument uses a chart which has straight rectangular coordinates. The counting rate is plotted as a linear function of the input counting rate. Instrument error, exclusive of the fluctuations caused by random variations in counting rate, is less than 2 percent of full scale. It has the additional advantage that three or more curves from different G-M tubes or scintillation counters can be plotted simultaneously on one chart if desired.

Principle of Operation

Nearly all G-M and scintillation counting at this time is done with scaling circuits combined with mechanical registers. These scaling circuits are widely used and fairly reliable in operation. They were used as a part of this instrument since the use of them makes possible the design of a simple and highly accurate type of counting rate circuit.

The instrument consists of a standard type of G-M scaler, a Leeds and Northrup Speedomax Recorder, and a relay circuit shown in Fig. 1. The principle of operation is as follows: The pulses from the G-M tube or a scintillation counter go to the input of the scaler circuit in the usual manner. They are scaled down and then, instead of operating the mechanical register in the scaler, they operate the high speed relay shown in Fig. 1. The relay is a single pole double throw type with a small condenser C_1 connected between the relay armature and ground. With the relay armature at its rest position, C_1 is fully charged by the fixed voltage E_1 connected to contact no. 4. With each register pulse, the armature of the relay moves momentarily to contact no. 2 and the condenser C_1 discharges into the large tank condenser C_2. This causes the voltage across C_2 to increase by a constant increment with each relay click.

After a fixed interval of time the switch S_1 closes and connects C_2 through a voltage divider to the input terminals of the Leeds & Northrup

Speedomax recorder. Switch S_1 is operated by a cam which is added to the Speedomax recorder. After the voltage across the condenser is plotted by the Speedomax, the cam moves to the next position and C_2 is completely discharged by S_2. Then the cam rotates further, S_2 is opened, and C_2 begins to integrate the relay clicks as before. This cycle of operations is repeated continuously, one point being plotted on the chart for each cycle. The position of each point is directly proportional to the number of relay clicks which have occurred and therefore to the counting rate during each interval of time.

The range of this instrument is changed simply by switching the scaling factor of the scaler. A scale of 64 is used for a full scale indication of 40,000 counts per minute, 32 for 20,000 counts per minute, etc., down to a scale of 2 for 1,250 counts per minute. Still lower ranges can be had by retaining the scale of two and switching in larger value condensers for C_1.

An example of the record obtained by this recorder from a scintillation counter is shown in Fig. 2. In this record, a point was plotted every 48 seconds, so each point represents the average counting rate of the counter over a 48 second period. Full scale is 40,000 counts per minute. The sample was first placed close to the counter for about an hour after which it was suddenly moved further away. It was moved several seconds after the beginning of a time period. It will be noted that when the counting rate changed, a point was plotted that is located between the former and latter counting rates. The reason, of course, is that the instrument always plots the average counting rate during each 48 second interval without regard to whether there are any variations within that period. To follow more rapid variations in counting rate, the printing time interval must be made shorter. Of course, the statistical variation of the points will then be greater. The time interval can be changed to 24, 12, or 6 seconds by substituting different cams with the proper number of teeth. Other intervals can be obtained by making changes in the original Speedomax mechanism.

Details of Design

In the system built here, a Nuclear Model 163 Scaler and a Speedomax Model G, 6 point, 0-10 Millivolt Recorder are used. The cam and cam-operated switches which were added to the Speedomax are shown in Fig. 3. The cam position must, of course, be adjusted so that its operation is synchronized with the switching of the recorder between its six input terminals.

It will be noted that the accuracy and stability of this circuit is dependent primarily upon the value of the resistors R_1 and R_2, the condensers C_1 and C_2, and the voltage E_1, assuming that the scaler and Speedomax are operating normally. The accuracy is not particularly dependent on the characteristics of any vacuum tubes or of the relay, as long as the register pulses do not arrive at such a high rate that the relay is not able to make contact for each pulse. The length of time the relay makes contact is not important since C_1 discharges completely into C_2 in a very short time. According to the manufacturer, the relay has been designed to follow a uniform pulse rate of 100 pulses per second which is much higher than necessary.

It is a characteristic of mercury relays, such as the Western Electric 275C, that the armature makes contact momentarily with the new contact before it breaks with the previous one. This means that current from the voltage source E_1 can flow for a short time directly into the tank condenser C_2. Fortunately, the length of time during which current can flow in this way is small. The resistor R_3 is used to limit the magnitude of this current. R_3 should not be made too large or it will prevent C_1 from charging fully when the relay armature is in the rest position. A trial of several relays showed that the charge transferred to C_2 by the momentary short circuit was constant for each relay, although the amount varied with different relays. The charge transferred by the momentary short circuit was in the order of only a few percent.

The net effect of this momentary short circuit is that C_2 gets a small extra charge with each relay click. As long as each short circuit lasts the same length of time, the overall accuracy of the instrument is not impaired. This seems to be the case in actual practice. The mercury relay was used in spite of this characteristic because of its high speed and quietness of operation.

Linearity

There are several things which must be considered in the design of this instrument in order for it to be linear. First, the value of C_1 should be very small in comparison with C_2 so that the voltage built up across C_2 in each time period is only a small fraction of the supply voltage E_1. Otherwise the charging curve for C_2 and the indication will begin to be appreciably non-linear. By using the circuit values given in Fig. 1, the deviation from linearity is less than 0.8 percent.

The linearity will be affected also if R_3 and R_4 are too large, because there will not be enough time for C_1 to charge and discharge completely during the cycle of operation of the relay. If the values given in Fig. 1 are used, however, the non-linearity introduced by this effect is completely negligible.

Calibration of the instrument is accomplished by adjustment of R_2. Once this is set for one sensitivity range, it will be just as accurately set for all the ranges as long as only the scaling factor is changed. If the value of C_1 is changed in order to provide more sensitive ranges, means should be provided to switch in different values of R_2 to compensate for slight inaccuracies in the values of C_1.

Summary

This paper describes a new type of counting rate recorder in which a series of points is plotted on a chart, the position of each point being directly proportional to the arithmetic mean of the counts received during fixed intervals of time. It consists of a G-M scaler, a Speedomax recorder, and an integrating circuit consisting of a mercury relay, condensers, and two switches operated by a cam which is added to the Speedomax recorder.

Acknowledgment

The author wishes to thank Dr. C. A. Tobias for his interest in this work. This work was performed under the auspices of the Atomic Energy Commission.

Information Division
scb/9-6-50

References

1. Kip, A., A. Bousquet, R. Evans, and W. Tuttle, Rev. Sci. Inst. 17, 323 (1946)

2. Gallagher, J., M. Sands, MDDC 1297

3. Schiff, L. I., R. Evans, Rev. Sci. Inst. 17, 456 (1936)

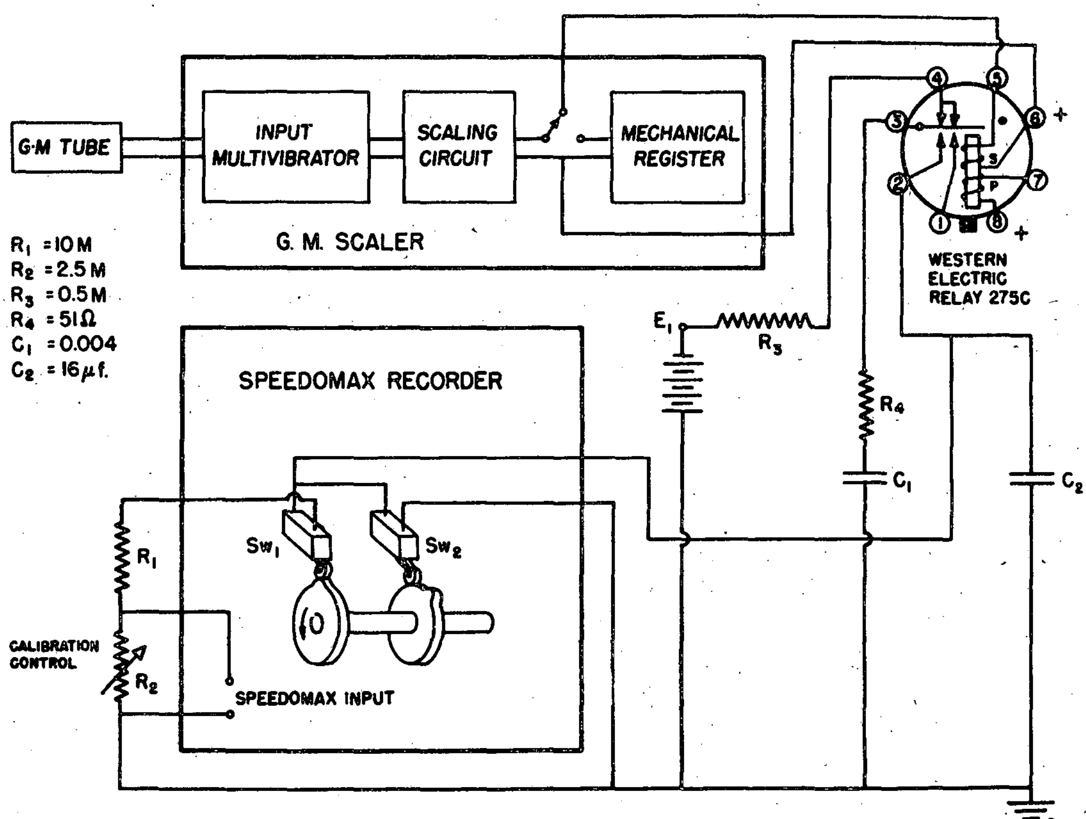


FIGURE I MU 724

Fig. 1

Wiring diagram of the counting rate recorder.

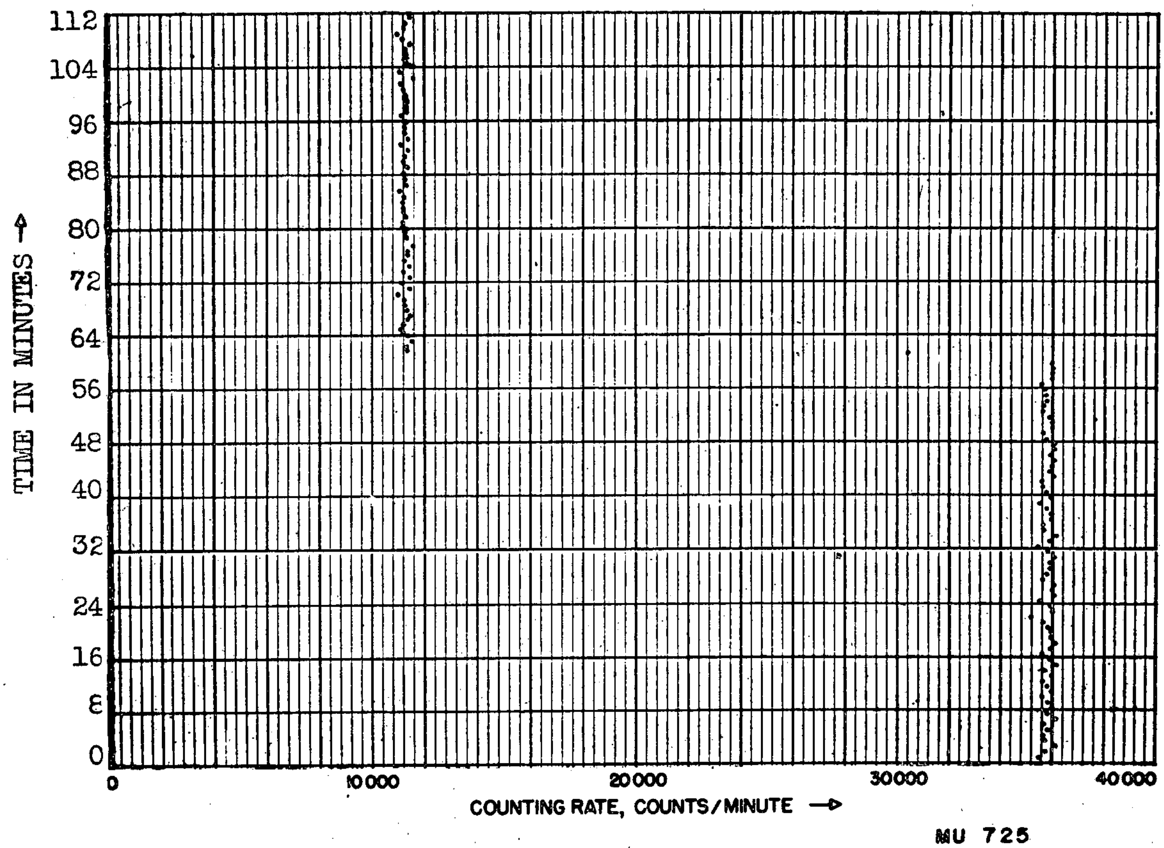
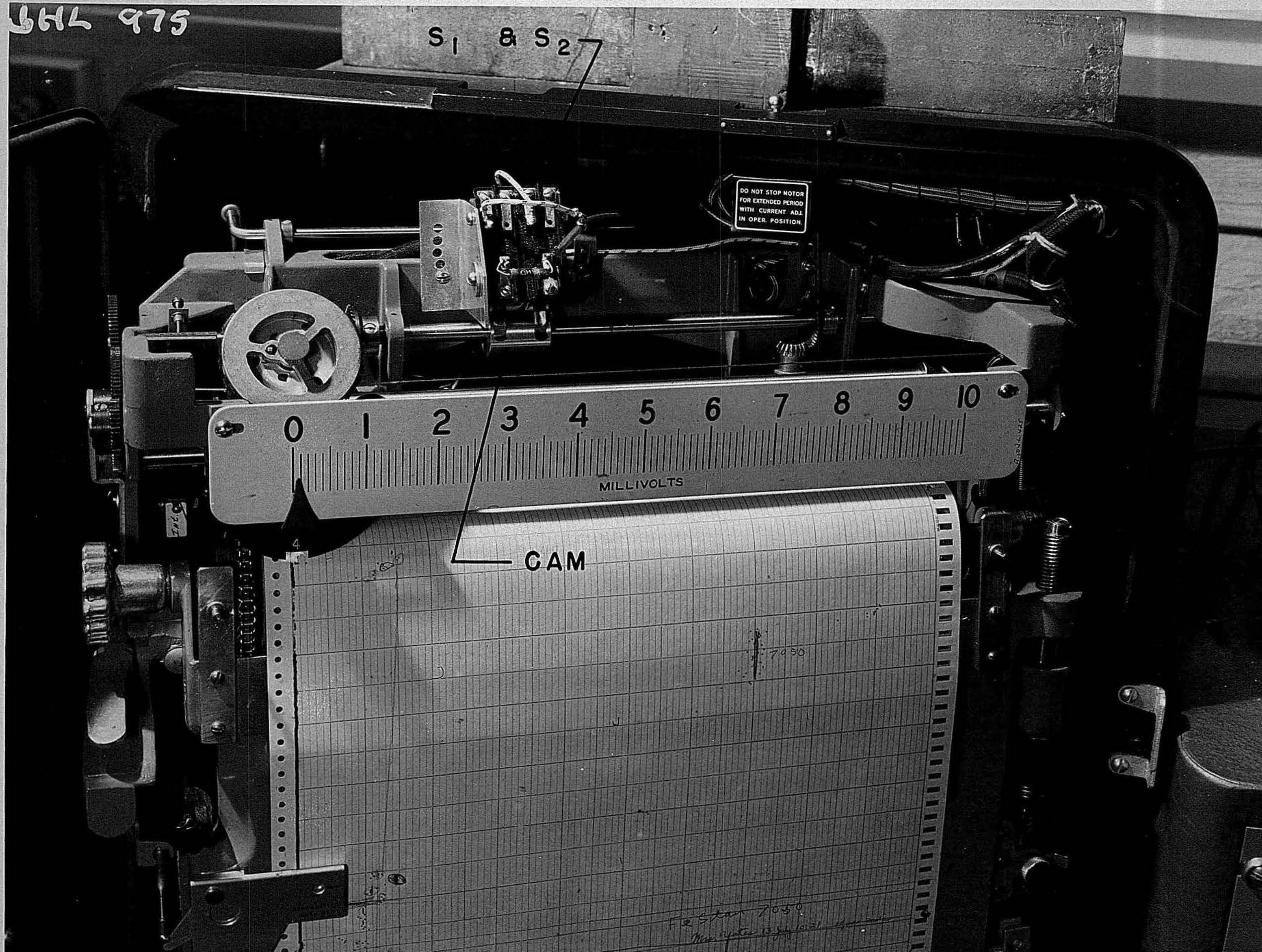


Fig. 2

This is an example of the record obtained.

FIG. 3 PHOTOGRAPH OF MODIFIED SPEEDOMAX RECORDER SHOWING INSTALLATION OF SWITCHES S_1 AND S_2 AND CAM.



OZ 958