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A Decade Scaling Circuit*

By

Ryutaro Ishiwari and **Kazunori Yuasa**

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I. Introduction

The principle of duo-scalers has become universally applied to construct scale-of-eight, scale-of-sixteen etc. in the experiments of high speed counting by linear amplifiers or Geiger-Müller counters. In busy works, however, a system of decade scaling circuit is earnestly desired, since it is more convenient for rapid summation and interpolation. The writers have designed and constructed a new decade scaling circuit of very simple construction but of extremely steady use. It is a modification of a circuit system of vacuum-tube scale-of-sixteen, and easily restored to its basic circuit by necessities.

II. Basic Circuit

Any type of the circuit used for the scale-of-sixteen may be modified into the decade scaling circuit. It was found, however, that a circuit devised by Higinbotham[1] seemed to be exclusively suitable for the purpose. While, in his circuit, Higinbotham used twin-triodes 6SN7-GT's or 6SL7-GT's, which are not easily obtainable in our country, we used more popular tube UY-76's. The diagram of the circuit is shown in Fig. 1. The amplitude discriminator which selects pulses and sharpens and equalises them was so modified as to fit for our purpose.

III. Description of Circuit

As it is shown in Fig. 1. the valves V_1, V_2, V_3,$\cdots\cdots V_{12}$ constitute themselves the original scale-of-sixteen. The diagrams in Fig. 2 (a) show the potential changes of the anode plates of V_3, V_6, V_9, V_{12} and V_{15} in their working state respectively.

* Under the same title the writers read a paper at the annual meeting of the Physical Society of Japan held at University of Kyoto, 21st May, 1948.

1. W. A. Higinbotham, J. Gallager and M. Sands. Rev. Sci. Instr., **18** (1947), 706.

These patterns are easily observed on a screen of a cathode-ray oscilloscope by applying regular signals of an adequate frequency to the input of the circuit.

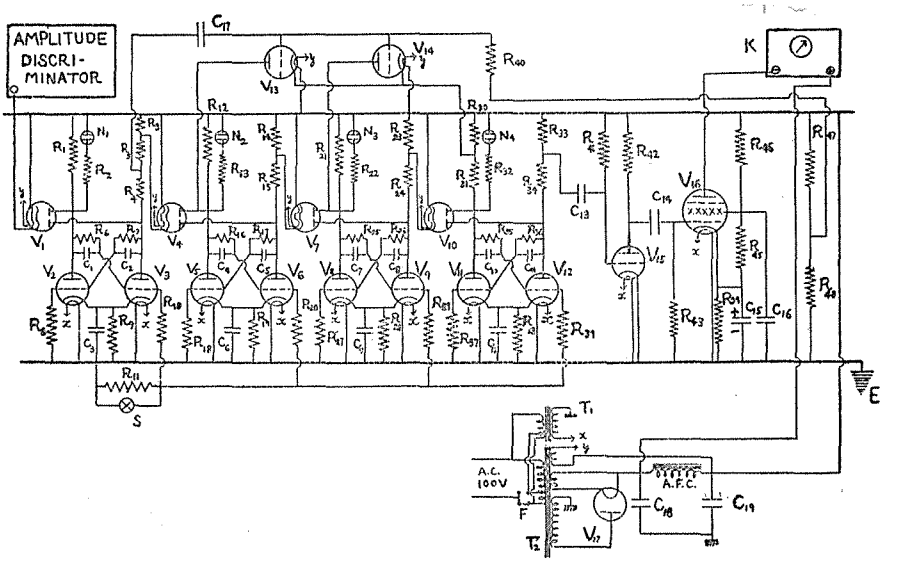

Fig. 1.

1) V···Vacuum tubes
1, 4, 7, 10 ····· Kt—6H 6A
2, 3, 5, 6, 8, 9, 11, 12, 13, 14, 15 ····· UY—76
16 ····· UZ—42
17 ····· KX—12F

2) R·····Resistances
1, 12, 21 ····· 40 K
2, 13, 22, 32, 43 ····· 1 Meg
3, 5, 14, 23, 33, 45 ····· 10 K
4, 9, 19, 28, 30, 31, 38, 46 ····· 20 K
6, 7, 16, 17, 25, 26, 35, 36 ····· 400 K
11, 40 ····· 100 K
8, 10, 18, 20, 27, 29, 37, 39, 42 ····· 200 K
15, 24, 34 ····· 30 K
41 ····· 2 Meg
47 ····· 25 K
48 ····· 60 K

3) C·····Capacitances
1, 2, 4, 5, 7, 8, 10, 11 ····· 50 pf
3, 6, 9, 12 ····· 0.01 μf
13 ····· 0.05 μf
14 ····· 0.005 μf
15 ····· 10 μf 50 V
16 ····· 2 μf 1000 V
17 ····· 100 pf
18 ····· 8 μf 1000 V
19 ····· 6 μf 1000 V

4) AFC···Audiofrequency choke
30 H 40 mA

5) T···Power transformer
1 ··· Primary 100 or 110 V 60~
Secondary 6.3 V 4A
2 ··· Primary 100 or 110 V 60~
Secondary 6.3 V 2A
5 V 1A
300 V 50 mA

6) S···Push button switch (normally closed)

7) K···Mechanical counter RIKEN-type (readjusted) working current 10 mA, resolving time 1/60 sec.

Now, in order to convert the scale-of-sixteen into the scale-of-ten, we adopt the most straightforward and simplest method. It is to insert a circuit system C_{17}, V_{13} and V_{14} parallel to the main, so that the ninth

signal plays a role of the fifteenth in the original circuit system. The potential of the cathodes of the triodes V_{13} and V_{14} are so adjusted that they may take about 210V when V_{11} is conductive, while they are maintained at 290V when it is nonconductive. As the potential of their anodes are 120V or 280V according as the tubes V_5 and V_8 are in the conducting state or not, so the relative potentials of their anodes against their cathodes are maintained negative so long as V_{11} is nonconductive. It follows that the inserted parallel circuit has no influence upon the basic circuit during it counts from the first to the seventh kick. In the eighth stage, however, V_{11} becomes conductive and the potential of the cathodes of V_{13} and V_{14} so drop that the potential of the plates of V_{13} and V_{14} becomes positive against those of the cathodes. But their grids are so properly biased as they conduct no current in this state.

(a) SCALE-OF-16

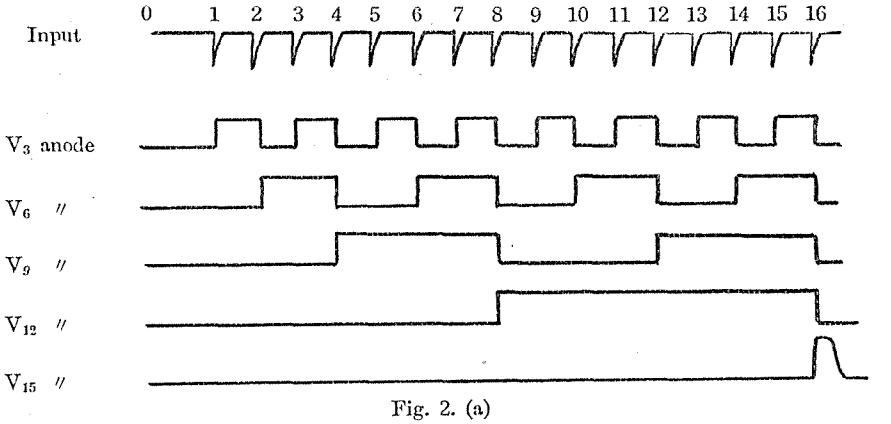

Fig. 2. (a)

Now, then, consider a positive signal is given to the circuit in this stage by the transition of the first pair. They at once rob currents from the plates of V_5 and V_8, resulting in the interchange of the states between the second and the third pairs, and the circuit recovers to its original state by the next, i. e. the tenth signal. The aspects of the conditions of V_{13} and V_{14} are shown in Fig. 2 (b).

IV. Construction

The amplitude discriminator and the scaling circuit is mounted on a $30 \times 28 \times 5$ (cm) chassis. There are no need of electric shieldings for vacuum tubes. The vacuum tubes are used without any precautious

(b) SCALE-OF-10

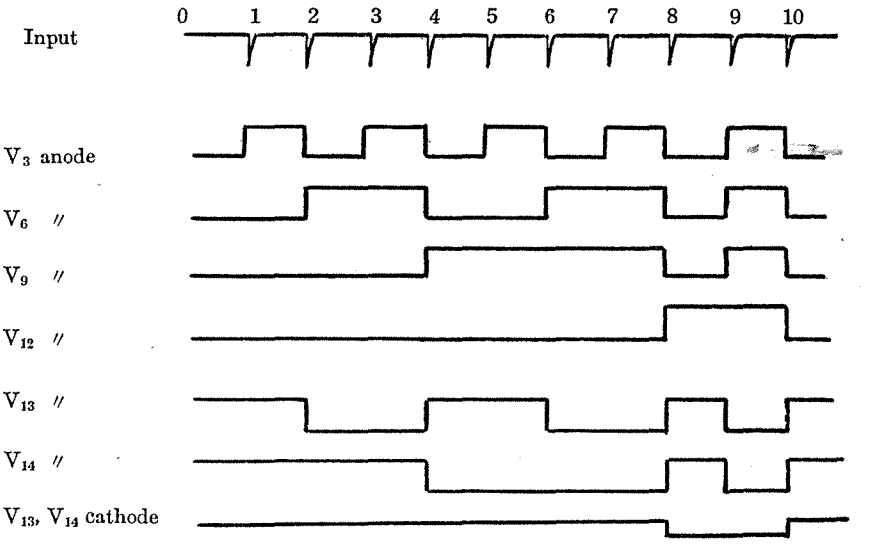

Fig. 2. (b)

selection. The only precaution is that the input circuit should be arranged apart from the register. The allowance of the values of registances marked on Fig. 1 is fairly large. The set is found to be easily handled and works reliably even though no special care is taken.

V. Test

To test the function of the circuit, we applied the sine-wavefrom a standard low-frequency oscillator (capable of generating oscillations ranging from 50 c.p.s. to 50,000 c.p.s.) and observed the oscillogram on the screen of the Braun tube. It was observed that it operated with success at frequenciesup to 50,000 c.p.s. No attempt has been made so far to determine the upper limit of the number of the reliable count, since the resolving time of this circuit is considered to be satisfactorily small for our present purpose.

The function of the aparatus was found to be satisfactorily reliable when the circuit was used in combination with the neutron-counter and linear amplifier system, and no need of readjustment has yet occurred.

In conclusion the writers wish to express their heartfelt thanks to Prof. Dr. B. Arakatsu and Prof. Dr. K. Kimura for their kind guidance and valuable suggestions throughout this work.