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Title Circuit Used To Measure Plate Characteristics in the Positive Grid Region

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CIRCUIT USED TO MEASURE PLATE CHARACTERISTICS IN THE POSITIVE GRID REGION

Purpose

To develop a basic pulse measurement circuit to be used as a design model for subsequent enlargement and at the same time make a bread-board set-up to be used in determining GL-592 plate characteristics.

Results

The circuit shown on K-69087-1A117 is the basic circuit recommended for this type of measurement. Pulse measurements have been made with a synchroscope at a repetition rate of 100 per second. The pulse is sinusoidal, 10 microseconds long. A plate family obtained with this set is attached. The voltage divider ratios and the resistors used in a particular case are dependent on tube operating characteristics. The procedures used to determine them are separately discussed in the report.

Circuit Description

The diagram shown on K-69087-1A117 describes the circuit used. It will be noted that the actual voltage on the anode during a pulse is determined by the capacitor voltage and the drop across the viewing resistor. Thus $e_b = E_{bb} - E_{ib}$ where E_{ib} is the peak signal voltage across the viewing resistor.

It will be noted that the voltage divider is directly connected grid to cathode. Capacitive coupling in the synchroscope removes the d-c grid voltage signal. Thus the actual grid to cathode a-c voltage is observed. The total grid voltage is $e_c = e_{cc} - E_c$. e_{cc} is dependent on the circuit through which it is applied to the grid. Therefore, when it is necessary to change grid current viewing resistors, the value of e_c should be checked and adjusted.

Procedure

There are three different types of data to be obtained with this equipment: total emission, plate current when $e_c = e_b$, and positive grid plate characteristics. All synchroscope readings are measured at the time when the grid signal is a maximum. This can be accomplished by adjusting the phasing controls on the synchroscope until the grid signal is located at some convenient reference. The synchroscope reads the signal by direct comparison.

Total emission is taken by connecting the plate to the grid. Total current is measured in the grid current viewing resistor.

To obtain i_b when $e_b = e_c$ a cut and try method is used. $e_b = E_{bb} - E_{1b}$ as stated before. Adjust E_b to the value which should give e_b to a first approximation. Adjust e_c. View E_{1b} and adjust E_b to give $e_b = e_c$. Check e_c. Then improve e_b and read all values.

Plate characteristics are obtained in the conventional manner. The data finally plotted will not give a series of points along some fixed value of abscissa but this does not limit the method. The data is most efficiently taken in the sequence indicated below:

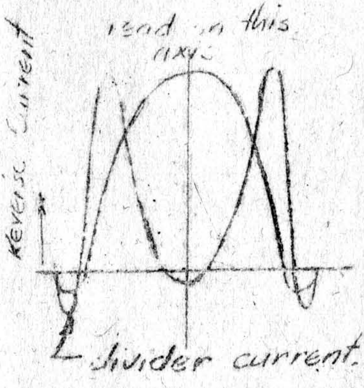
E_f E_{bb} E_c F^* e_{cc} e_c F^* E_{1b} i_b F^* E_{1c} i_c e_b

*F indicates multiplying factor of the equipment.

In taking these data it is essential that e_c be checked whenever E_{bb} is varied because of the effect of E_b on grid loading.

Discussion

In the reading of grid current it is interesting to note that reverse grid current can be definitely checked as secondary emission. If a high plate voltage is applied to the tube and negative grid current flows, this negative grid current is secondary emission if the maximum negative current during the driving cycle is not continuously increased by increasing the grid drive. The sketch shows grid current values at two different values of grid drive.



In the development of this set considerable thought was given to the use of current viewing amplifiers. Certain conclusions regarding their use follow. An amplifier is desirable whenever E_b is less than 500 volts because the error of determination of e_b ($e_b = E_b - E_{1b}$) may then become important. An amplifier must be a d-c amplifier (with capacitive input so that the comparing signal doesn't burn out the veiwing resistor) and connections to the deflection plates of the scope must be direct if direct calibration (comparison method) is to be used. Use of a calibrated amplifier with a-c coupling is to be avoided because of the difficulty of checking and maintaining calibration. Further, when using an amplifier, extreme care must be exercised in the mechanical arrangement of parts if difficulties from circuit inductance are to be avoided. The resistor used must be extremely non-inductive because the inductive effects are also amplified. It appears that the use of a current viewing amplifier is warranted only in the screen circuits of pentodes and tetrodes.

If a special unit of this type is to be made, it would be well to modify the synchroscope to provide direct connection of the deflecting electrodes to the circuit. This would then make it possible to read e_o direct rather than by reading e_{oc} and E_c. It would also make reading the oscilloscope easier if essentially positive pulses were connected to one deflecting electrode and negative pulses were connected to the other, thereby making measurement a simple routine, therefore more accurate.

Design Considerations

1. Voltage Divider

In the voltage divider two things must be considered: phase shift and stray effects. Phase shift can be avoided by making the RC product of each section of the divider equal. This should include all measurable stray effects such as cable loss and capacitance. To avoid leakage errors the resistance per section should be made as low as possible without causing an error in current viewing. C should be as large as possible, limited in the same way. Connection to the divider should be made through a calibrated cable. Between the cable and the divider there should be a damping resistor to minimize shock excitation of the cable.

If various sections of the divider are connected to a selector switch, each lead to the switch should be separately damped to minimize cross interference at the switch. The voltage divider and all viewing leads should be thoroughly shielded if inductive voltages from the high current leads are to be avoided.

2. Current Viewing Resistors

Non-inductive resistors are absolute requirements. Sprague Koolohms are quite satisfactory in the 50 ohm level. For lower resistance special resistors must be made which have the return circuit closely associated with the signal lead. Thus circuit inductance is eliminated. Resistors of the type for measuring 1 microsecond pulses are satisfactory. It is recommended that a minimum viewing resistance of 1/3 ohm be established. If currents above the level directly viewable across this resistor are encountered, it is suggested that a voltage divider be employed. Thus a reasonable ratio (L/R) can be maintained.

3. Pulse Length

Shock excitation and inductive voltages are the causes for error in this system. Both of these possibilities are reduced by the use of long sinusoidal pulses.

4. Use of Pulse Transformer

The initial set-up developed positive pulses across a resistor connected from cathode of the thyratron to the pulse line. This system could have no pulse ground (without causing difficulty in the measuring circuit) so that stray ground currents effected grid current readings. This was eliminated by using a 1:1 inverting pulse transformer. The pulser load should be connected on the secondary of the transformer to minimize the effect of grid current on the pulse voltage wave shape.

5. Energy Storage Capacitor

The energy withdrawn from the capacitor tends to reduce the capacitor voltage. Since $Q = C\triangle V = \int i\,dt$, it is easy to determine the voltage drop under various conditions. For sinusoidal pulses, reading at the middle of the pulse, $C\triangle V = \frac{I_b \times \text{pulse length}}{2\pi}$

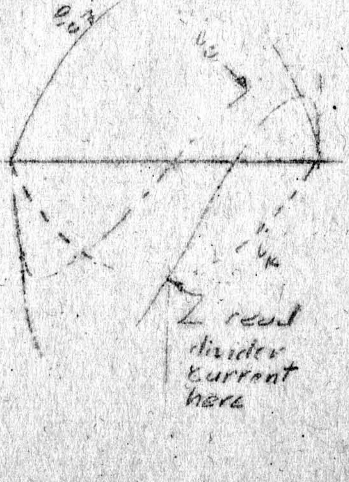
If the capacitor used is not sufficiently non-inductive, the drop will be greater than the calculated value. If this occurs it may be expedient to parallel the energy storage capacitor with a 10% storage RF capacitor.

Calibration

1. Voltage Divider

The voltage divider is calibrated by reading a signal direct and by the divider to obtain the dividing ratio. This method is applicable when the ratio is less than 5:1. The experience in this design indicates that the use of measured capacitors and resistors enables one to predict the factor as accurately as it can be measured. To check on the circuit time constants compare the phase of the direct and divided signals. They should be in phase.

The divider and grid-cathode capacitance may have currents which are large enough to influance subsequent grid current readings. A curve of divider current vs. divider voltage can be prepared to correct readings for instrument error.



2. Current Viewers

Non-inductive resistors should be used. Measure their resistance with a Wheatstone Bridge. Observe the current pulse obtained in the circuit. It should be in phase with the applied voltage. If it is not in phase the phase angle measured can be used to compute L/R by $\tan \theta = \frac{\omega L}{R}$

Then $Z = R\sqrt{1+\theta^2}$ when θ is small. This value of Z should be used to determine i from the voltage measured.

3. Energy Storage Capacitors

The drop in plate voltage caused by removal of energy from the storage capacitor can be determined by connecting the synchroscope across the capacitor through a mica or other high grade capacitor. The voltage observed is the drop in voltage across the capacitor. Read when the grid voltage is a maximum.

P. W. Crapuchettes P.W. Crapuchette
ENGINEERING Nov. 23, 1945
TUBE DIVISION

Countersigned: KC DeWalt
Nov 23, 1945

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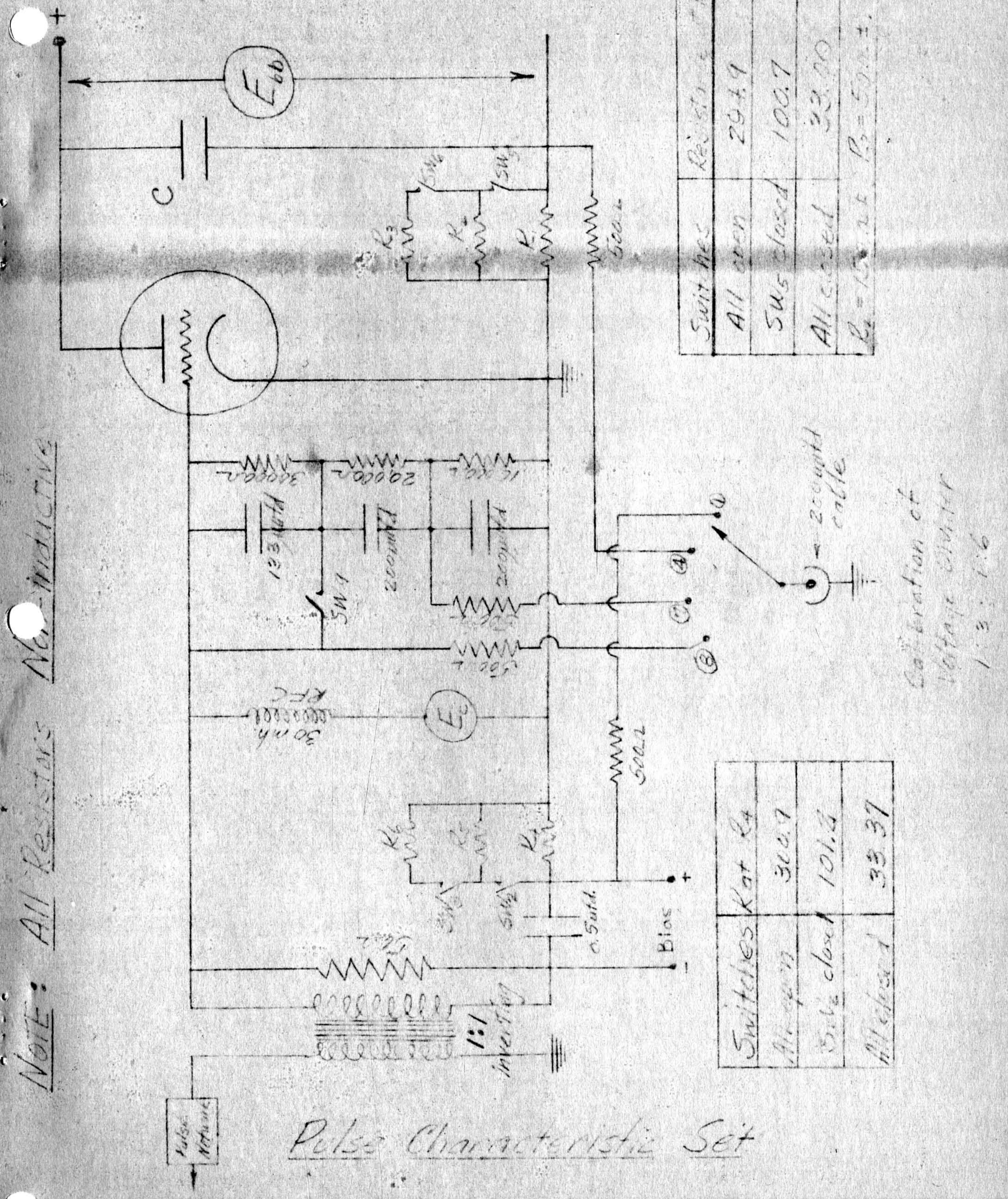
TA Elder
KC DeWalt
EF Peterson
CR Knight
BS Angwin
PW Crapuchettes
WB Gillen
(OW Pike
(AC Gable

THIRD ANGLE PROJECTION **K-**

K-69087-1A117



Note: All Resistors Non-inductive

Switches	Resistance Ω
All open	294.9
SW_5 closed	100.7
All closed	33.20
$R_2 = 15Ω \pm 1$	$R_3 = 50Ω \pm$

Switches	R at R_4
All open	300.7
SW_2 closed	101.2
All closed	33.37

Calibration of Voltage Divider 1:3:1.6

Pulse Characteristic Set

REVISIONS	MADE BY R.W. Cr	INSPECTED BY NOV-5-45 A.P.	JK-7489	9
	GENERAL ELECTRIC WORKS Schine	K-69087-1A117 SHEET NO._____ CONT. ON SHEET_____		a PRINTS TO

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