311.61

PBM PBM
WAB WB
~~PBS PBS~~
~~RHBE~~ RHB
CWH CMF

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GENERAL ELECTRIC COMPANY

SCHENECTADY, N. Y., U. S. A.

DATA FOLDER No. 72171

Title: Constant Current Emission Test Circuit

By

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CONSTANT CURRENT EMISSION TEST CIRCUIT

Electronic Tube Engg Dept. October 21, 1943

Abstract:

An electronic circuit for making DC emission voltage measurements under constant current conditions in vacuum tubes is described. The circuit also includes an electronic timer for tube protection and an electronic overvoltage relay for meter protection.

Background

Specifications on lighthouse tubes call for a DC emission test. Since, under constant voltage conditions with grid and anode connected, the emission current may vary over a wide range and high emission tubes may pass currents in excess of safe limits, a constant current test is specified. To further protect the tubes, a maximum time limit is also specified on the emission test.

Purpose

This folder is prepared to assist the factory in converting the constant voltage emission test circuit used in lighthouse tube test sets to a constant current circuit. Provision is also made to automatically limit the test duration so that specifications on the maximum time that emission voltage may be applied will not be exceeded.

Constant Current Regulator

Constant current regulation is obtained through utilization of the flat plate characteristics of the 6L6 type tube. By using cathode bias, the plate current of this tube will regulate over a wide range of plate voltages to a value determined by the setting of the cathode resistor. This allows a load (in this case the tube under test) to be placed in series with the plate supply across which a voltage drop may appear without affecting the current regulation.

The screen voltage of the 6L6 regulator tube is held constant through use of two voltage regulator tubes. The variation in plate voltage therefore does not appear between screen and cathode but rather across R1.

By placing a high resistance voltmeter in parallel and a milliammeter in series with the load it is possible to read the voltage appearing across the load for the current being regulated through it. This is the condition called for in specifications on some vacuum tubes.

Meter Protection Circuit

In the current regulating circuit described, the potential across the load may rise to the full value of the supply if the load resistance is high enough during the emission test. This may result from poor contact to the tube elements, very poor emission, or in an air tube or a tube with burned out or unenergized heater. Since the normal test voltage across the tube under test (Tu6 in figure 1 and 2) is in the order of 5% of total supply voltage, a meter burnout would result if one of these conditions existed.

To protect the voltmeter from burnouts, a meter protection circuit using a GL-502 or 2050 tube is used (Tu4). During a normal emission test, this tube is firing, thus closing relay Ry1 and allowing current to flow through the tube under test. Should a high voltage appear across the voltmeter, the same voltage will also appear across R4. This will raise the negative bias on Tu4 and cut off current flow through this tube within one-half cycle of the 60-cycle plate supply. When plate current is cut off, relay Ry1 opens, removing the high voltage from the voltmeter. R4 may be adjusted to cut off Tu4 at full scale voltage.

Low current plate voltage is supplied to Tu4 through use of an inverted 1 ampere filament transformer (T1). This eliminates the need for a larger 1:1 isolating transformer and a series current limiting resistor.

Timing Circuit

In order to protect tubes being emission tested from damage due to overload current of excess duration, a maximum time limit is usually specified beyond which DC emission test voltages should not be applied. Since the ability of test operators to accurately time each test is questionable, a timing circuit is described which will automatically remove the test voltage from the tube under test after a predetermined interval. This circuit is similar in part to the meter protection circuit.

In the timing circuit, the tube (Tu5) plate supply (T4), and relay (Ry2) are identical to those used in the meter protection circuit. The tube is prevented from firing by a negatively charged condenser (C1) connected between grid and cathode. The charge on the condenser is allowed to leak off through an adjustable resistor (R3). When the charge reaches a low enough value, the tube fires, opening relay Ry2 and removing the test voltage from the tube under test. The time interval is controlled by the resistor R3.

The control condenser is switched from the charging line to the grid of Tu5 by a SPDT relay. This relay is energised when the emission test key is thrown to the emission test position.

Protection Features

Probably the only potential cause of failure is that one of the tubes may become inoperative due to heater burnout or loss of emission after its normal life.

If the current regulator tube fails, no voltage appears across the tube under test and therefore no damage is done.

If the meter protection tube fails to operate, relay Ry1 does not close and no voltage appears across the tube under test.

If the time delay tube fails to operate, the failure will immediately be detected by the operator and she will open the emission key. Under this condition the tube under test is no worse off than it is at present when no time switch is used.

Installation

The basic circuits for the constant current emission test are given in Figure 1 and 2. The only difference between the two circuits is in the placement of Tu1, the current regulating tube. The Figure 2 circuit is preferable since the screen voltage regulator tubes are connected to the same point as the cathode resistor while in Figure 1 they are connected across the regulator tube and the tube under test. In the experimental set-up tried, the figure 1 circuit resulted in a current variation of 2% over the voltage range required. ($E_s = 0$ to 10 volts, $I_s = 40$ ma). This variation is objectional only if an absolute voltage measurement is needed over the entire testing range. If the test is to be used as a "pass or fail" indication, the regulator tube may be adjusted to give the required current at the limit voltage and either Figure 1 or Figure 2 may be used with equal accuracy.

To replace an emission circuit similar to that of Figure 3, it is necessary to connect the Figure 1 circuit as shown in Figure 4. If the Figure 2 circuit is to be used, point D is connected directly to a 250 volt DC source of supply and the test socket must be revised to accommodate Tu1.

If the constant current emission test is to be used as an individual piece of test equipment, it is recommended that the Figure 2 circuit be connected according to Figure 5.

Voltmeter Considerations

For best results a voltmeter of approximately twice the emission test limit voltage should be used. This meter should have as high a terminal resistance as possible since part of the current regulated by Tu1 flows through it. It can be shown that the error in voltage reading due to the insertion of the voltmeter is represented by the formula:

$$\% \text{ error} = 100 \frac{E_1}{E_1 + R_m I_o}$$

where E_1 - tube drop with voltmeter removed (volts)
R_m - meter resistance (ohms)
I_1 - constant current (amperes)

If, however, the test is to be a pass or fail indication, the current may be regulated to a value equal to the sum of the current through the tube under test and the voltmeter across the tube. This will make the voltage indicated correct at the limit point only. It is recommended that the meter be at least a 1000 ohm per volt instrument.

Operation

After installation, R2 should be set at maximum resistance, R5 to minimum resistance and R4 to the negative end of the potentiometer. A fair emission tube should be placed in the test socket and emission voltage applied. Adjust R5 until the delay time is correct. Adjust R2 until the desired current through the tube under test is reached. Remove the tube under test and substitute an adjustable resistor of approximately twice the resistance of the tube to be tested. Apply emission voltage and adjust the dummy resistor until the maximum allowable meter voltage appears on the voltmeter. Adjust R4 until the meter protective circuit cuts off the test voltage. Recheck the action of this protective circuit with higher resistance values to make sure the voltage is removed before the voltmeter reaches full scale. The worst test condition is that which occurs with no tube or dummy resistor in the socket.

It may be necessary to adjust R4 and R2 alternately as the R2 adjustment affects the R4 adjustment.

B S Angwin

BS Angwin
October 21, 1943

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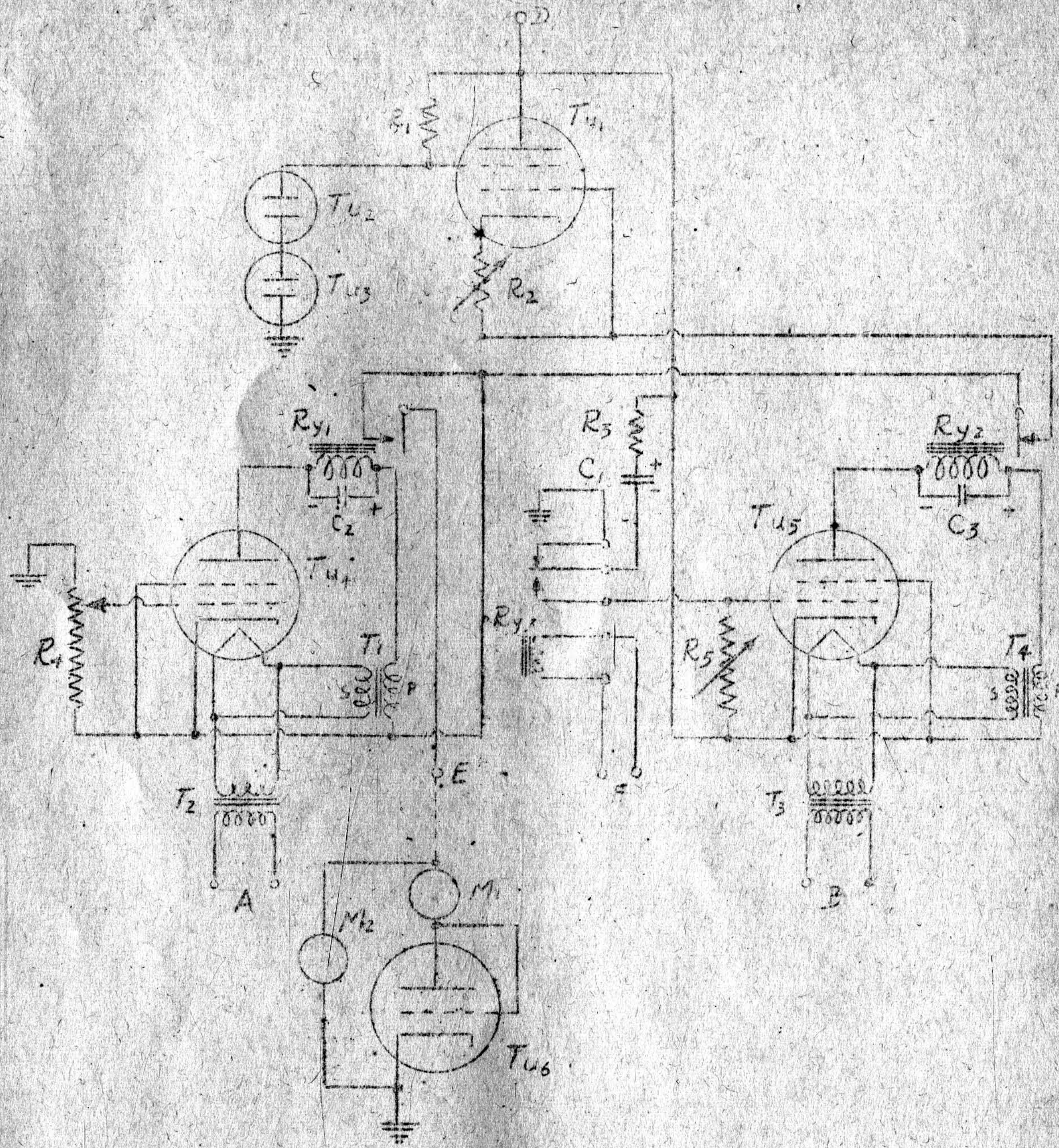

D
R1
Tu1
Tu2
Tu3
R2
R3
C1
Ry1
C2
Tu4
R4
T1
T2
E
A
Ry2
C3
Tu5
R5
T4
T3
B
M1
M2
Tu6

FIG 1

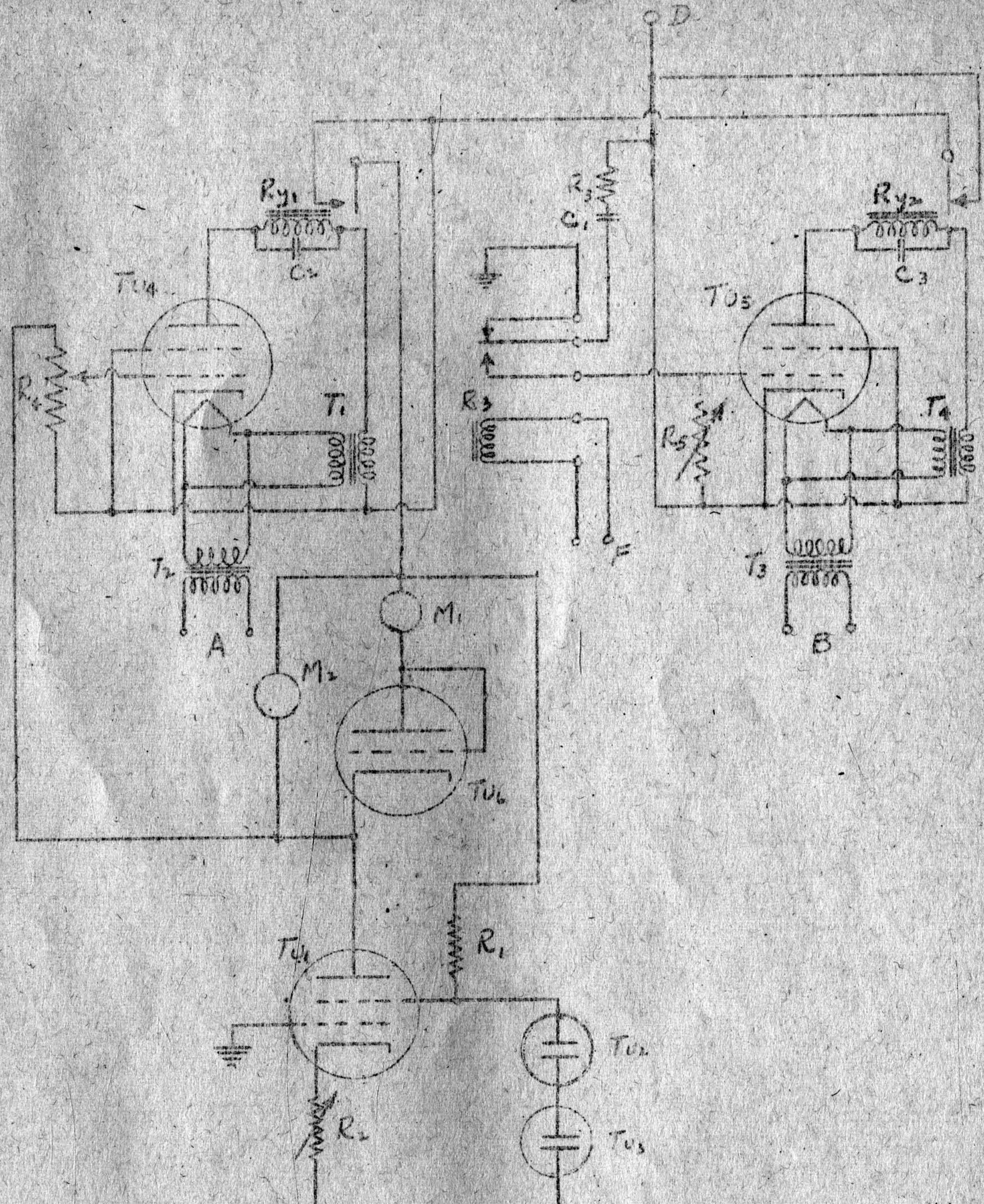
D
Ry1
C2
Tu4
R4
T1
T2
A
R3
C1
R3
F
Ry2
C3
Tu5
S1
R5
T4
T3
B
M1
M2
Tu6
Tu1
R1
R2
Tu2
Tu3

FIG 2

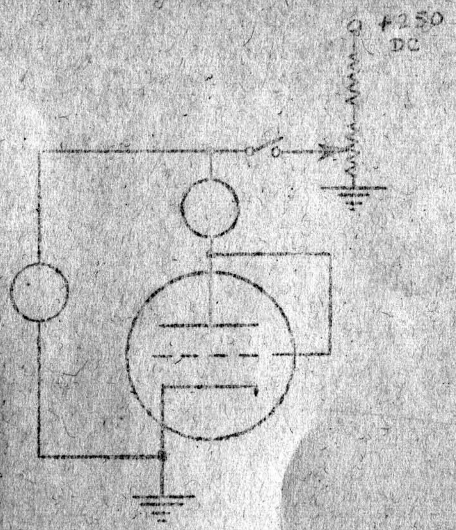

Fig 3

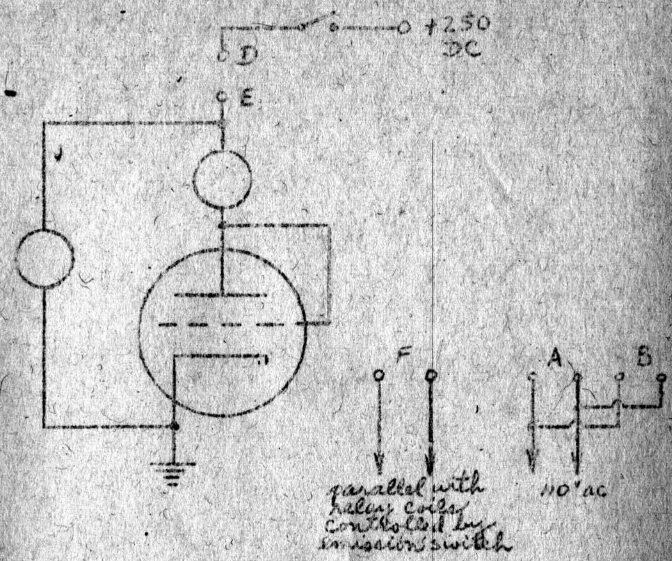

Fig 4

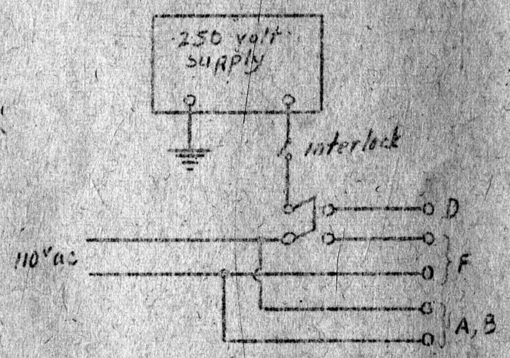

Fig 5

B.H.
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Tu_1 = 6L6
Tu_2 = VR75
Tu_3 = VR75
Tu_4 = GL502 or 2050
Tu_5 = GL502 or 2050
Tu_6 = Tube under test

T_1 = T19F80 Thordarson Transformer
T_2 = " " " " " " " " " " " " "
T_3 = " " " " " " " " " " " " " "
T_4 = " " " " " " " " " " " " " "

Ry_1 = Western Electric Telephone Relay 6000
Ry_2 =
Ry_3 = SPDT Relay (CR2790 - E100A2 may be used)

M_1 = 100 ma DC meter
M_2 = 15 v DC meter (high resistance)

R1 = 10,000 Ω 2 watt
R2 = 1,000 Ω 25 watt potentiometer wire wound*
R3 = 1,000 Ω 1 watt
R4 = 100,000 Ω 1 watt potentiometer
R5 = 100,000 Ω 100 watt wire would adjustable resistor.

C1 = 4 mf, 450 volts
C2 = .25 mf, paper
C3 = .25 mf paper

* Better current control may be obtained by using higher power resistors as more steps are available.