ELECTRON TUBE FILAMENT CIRCUIT ADJUSTMENT REFERENCE VOLTAGE AND REFERENCE CURRENT METHODS

1. GENERAL

1.01 **This section describes methods of adjusting electron tube filament circuits in offices having regulated filament battery, i.e., where the distributing fuse panel voltage is maintained within ± 0.5 volt of the mean voltage. The methods covered in this section do not apply to those circuits employing type 310A and 311A electron tubes authorized for 9-volt heater circuit operation. In such cases reference should be made to the circuit drawings and if the necessary information does not appear thereon, reference should be made to Section 024-721-801. Two methods are described as follows:**

(A) Reference Voltage

(B) Reference Current

1.02 This section has been revised to define the terms used in the section; to add a reference to circuits employing type 310A and 311A tubes authorized for 9-volt heater circuit operation; to specify the establishment of a reference voltage for each order of current for each fuse panel which supplies circuits operating on currents of different orders; to add a reference to the 98F resistance and supply information concerning substitute resistances for 101FA, 101L, and 102L electron tubes; to modify the methods used in determining reference voltage and reference current; to remove the chance of appreciable error in setting up reference fuse panel voltages which would result if meters of different resistance were used in determining these voltages and in adjusting filament currents, particularly where grid bias is obtained by filament drop; and to make various minor changes in the text. Since this reissue covers a general revision, the arrows ordinarily used to indicate changes have been omitted.

1.03 Definition of terms:

(a) "Mean" Fuse Panel Voltage: The mean fuse panel voltage is defined as "the arithmetic average of the readings of a voltmeter connected to a fuse panel under normal load when the voltage at the power board is at its upper and lower limits as determined by the settings at which the voltage alarm or automatic voltmeter relay operates." "Mean" fuse panel voltage is used for installation adjustments. "Reference voltage," used for maintenance, is lower than the "mean" voltage by the drop in the filament circuit.

(b) Reference Voltage: The reference voltage of a fuse panel is defined as "the arithmetic average of the readings of a voltmeter connected in series with a filament circuit, in which fixed resistances have been substituted for the electron tubes, wired to a fuse panel under normal load, when the voltage at the power board is at its upper and lower limits as determined by the settings at which the voltage alarm or automatic voltmeter relay operates."

(c) Reference Current: The reference current of a filament current checking circuit is defined as "the arithmetic average of the readings of an ammeter in series with the filament current checking circuit when the voltage at the power board is at its upper and lower limits as determined by the settings at which the voltage alarm or automatic voltmeter relay operates." Thus "reference current" is the current read in the filament current checking circuit when the deviation from "reference voltage" is zero.

1.04 It is important that the reference voltage or reference current for each fuse panel should not vary beyond the limits shown in Paragraphs 3.02 and 3.24. Accordingly the reference values should be checked whenever any modification in the equipment is made which may affect the reference values, such as power plant changes or changes in the load on a fuse panel.

1.05 The various values in Tables 1, 2, and 3 and the information covering the type of resistances to be inserted in the tube sockets are provided for use when these data are not shown on the circuit drawing. Reference should first be made to the circuit drawing and if the necessary information does not appear thereon then the values shown in this section should be used.

1.06 In certain cases, such as the types J and K carrier unattended offices using a 152-volt power plant, the general method shown in

this section does not apply and special procedures are necessary as covered on the circuit drawings.

1.07 These methods can not be applied in non-regulated battery offices or in regulated battery offices which are equipped with ballast lamps, but they are applicable to these circuits in regulated battery offices provided the ballast lamps have been replaced by No. 96A resistances or their equivalent.

1.08 The reference voltage method (A) is preferable and should be used whenever a suitable voltmeter is available.

1.09 The reference current method (B) is applicable only where a filament checking curcuit is provided.

2. APPARATUS

(A) Reference Voltage

2.01 98-type, 113A-, or 114-type Resistances as required to replace the electron tubes (see Paragraph 3.06).

2.02 Weston Model 1 or Model 45 Ammeter, scale 0 to 0.6 and 0 to 1.8 amperes, or equivalent (see Note 2).

2.03 Weston Model 1 or Model 45 Voltmeter, scale 0 to 30 volts, or equivalent (see Note 2).

2.04 One W2BC Cord equipped with a No. 304A Plug (2W26A) or No. 347 Plug depending upon the particular filament circuit jacks involved. If a No. 347 Plug is required, the W2BC Cord should be modified locally.

2.05 SPST (single-pole, single-throw) Switch or equivalent key.

2.06 165- or 258-type Plug.

2.07 Short lengths (not over two feet each) of rubber-insulated stranded wire not smaller than No. 18 gauge or two leads of L20 Jumpers in parallel, for connecting meters and switch.

(B) Reference Current

2.08 Resistances as covered in Paragraph 2.01.

2.09 Ammeter as covered in Paragraph 2.02.

2.10 Two W2BC Cords as covered in Paragraph 2.04.

2.11 DPDT (double-pole, double-throw) Switch or equivalent key.

2.12 165- or 258-type Plug as covered in Paragraph 2.06.

2.13 Wire as covered in Paragraph 2.07.

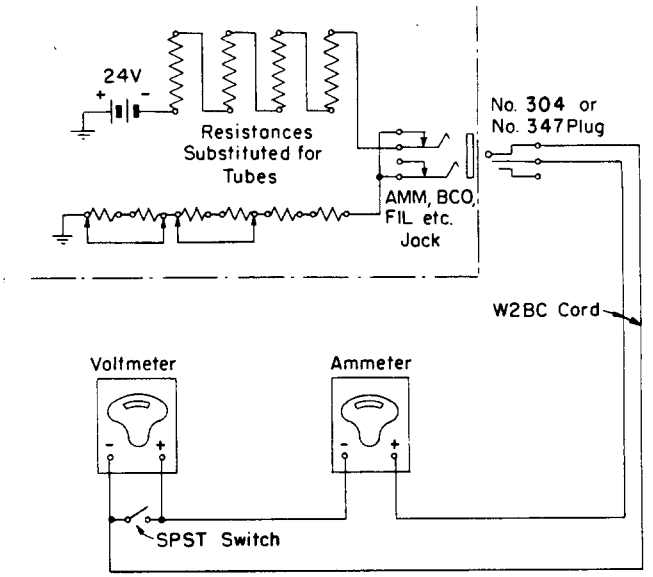

Fig. 1

Note 1: On account of the wiring in some circuits it will be necessary to reverse the wiring to the meters in order for the meters to indicate properly.

Note 2: Since the requirements and methods in this section assume the omission of routine filament current measurements, accuracy is important. Therefore, the meters used should have a rated accuracy of 1/2 of 1 per cent or better. The voltmeter should have a nominal resistance of not less than 100 ohms per volt. The meters, when testing should be separated at least 12 inches from each other and at least 6 inches from other metal, such as the frames of the relay rack bays, power boards, etc. If model 45-type meters are used, these precautions are not necessary.

3. METHOD

(A) Reference Voltage

3.01 Determination of Reference Voltage: A reference voltage shall be determined for each distributing fuse panel from which the filament circuits of the various equipment circuits involved may be supplied and for each

order of current involved, i.e., 0.25, 0.5, and 1.0 ampere, for each fuse panel which supplies circuits operating on currents of different orders.

3.02 Any reference voltage once determined for any fuse panel should remain within 0.2 volt as long as the mean floating voltage of the office battery is not changed or the load on the fuse panel remains reasonably constant. It should also be the same within the accuracy of measurement for all filament circuits employing the same fuse panel.

Note: **Prior to determining the reference voltage, the high-low voltage alarm in the case of manually or automatically regulated batteries or the automatic voltage regulating equipment should be checked to insure that this equipment is functioning within its specified limits. This check should be made by connecting the model 1 or model 45 voltmeter across the battery at the bus bars to which the voltage alarm relay is connected and raising and lowering the voltage to the settings of the equipment. Adjustments as required should be made as covered in sections applying to this equipment.**

3.03 The procedures which should be followed for the determination of the reference voltage are given in the following paragraphs. A 2-way talking circuit will be required between the location of the equipment at which the test is made and the attendant in the power room who is assisting in the test.

3.04 Insure that the normal load is being drawn from the fuse panel for which the reference voltage is to be determined.

3.05 Remove from service the equipment associated with one filament circuit which is connected to the selected fuse panel. In selecting a filament circuit for test, one involving push-pull carrier amplifiers should not be used.

Caution: The filament circuit should always be turned off by inserting a 165- or 258-type dummy plug, as required, in the filament circuit jack before removing a tube from a socket.

3.06 Substitute resistances for the electron tubes in the filament circuit as follows:

Type of Resistances	Type of Tubes
98A	101D, 104D D-86326 and D-86327
98B	101F, 101FA 101J and 102L
98C	102F
98D	102D and 102G
98F	101L
113A	310A
114A	311A
114B	338A

Note: In certain circuits. such as SD-61014-01, 1A Carrier Pilot Channel Terminal, it will be necessary to block the alarm relay in the plate circuit temporarily, as an alarm lamp is fed through the filament circuit jack and incorrect current flow readings would be obtained.

3.07 Referring to Fig. 1, insert the plug on the cord to which the meters are attached into the filament circuit jack.

3.08 With the voltmeter short-circuited check to see that the filament current is within the specified limits shown on the circuit drawing or within the limits shown in Table 3, if the values are not shown on the circuit drawing.

3.09 Connect the voltmeter into the circuit by opening the SPST switch. Observe the voltage on the 30-volt scale and have the power attendant adjust the battery over its range. Read with the best possible accuracy (within 0.05 volt) and record the voltages when the battery is at its high and low limit, as determined by the operation of the high-low alarm in manually operated power plants, or by the operation of the automatic equipment in automatically regulated plants. Care should be taken not to override the settings of the voltage alarm or automatic voltmeter relay. In order to determine these voltages accurately it may be necessary to repeat the readings several times and take the average, rejecting any extreme variations. Have the power attendant return the battery voltage to normal.

3.10 Obtain the arithmetic average of the high and low readings recorded in Paragraph 3.09. This average is the REFERENCE VOLTAGE for the particular fuse panel and for the order of current involved. The reference voltage and the serial number and resistance of the voltmeter used to obtain the voltage should be recorded for each fuse panel and for each order of current in the fuse panel records associated with the fuse panel or panels for subsequent reference.

3.11 Either proceed with the adjustment as covered in Paragraphs 3.12 to 3.22 or remove the resistances from the tube sockets and reinsert the electron tubes and restore the equipment to service.

3.12 Adjustment of Filament Circuit Resistance: If not already known, the reference voltage should be determined for the distributing fuse panel which supplies the filament circuits to be adjusted as covered in Paragraphs 3.01 to 3.11.

3.13 The accuracy of the adjustments covered herein depend upon the establishment of a definite voltage current relationship, therefore they should not be undertaken during periods when the battery voltage is fluctuating rapidly.

3.14 The meters used in making the adjustment of the filament circuits should be the same (or of the same resistance) as the ones used for determining the reference voltage. The 2-way talking trunk to the power room attendant will not be needed in these procedures.

3.15 Insure that the normal load is being drawn from the distributing fuse panel.

3.16 Remove from service the equipment associated with the filament circuit to be adjusted (see caution following Paragraph 3.05).

3.17 Substitute resistances for the electron tubes in the filament circuits, in accordance with the list in Paragraph 3.06.

Note: In the case of push-pull carrier amplifiers, the filament battery in the branch of the amplifier not under test should be cut off and a tube in that amplifier branch should be removed.

3.18 Referring to Fig. 1, with the SPST switch closed insert the plug on the cord to which the meters are attached into the filament circuit jack.

3.19 Read the filament current and immediately connect the voltmeter into the circuit by opening the voltmeter short-circuiting switch. Read the voltage and close the short-circuiting switch. The voltmeter should not be left connected longer than necessary for a reading to be obtained. Determine the deviation of this measured voltage from the reference voltage.

3.20 Adjust the resistances in the filament circuit, repeating Paragraph 3.19 after each adjustment until the current-voltage relation, as shown on the circuit drawing or as given in Table 2, is obtained. Where the current value for zero deviation from reference voltage is not shown on the circuit drawing the values shown in Table 1 may be used.

3.21 Remove the resistances from the tube sockets and reinsert the electron tubes. Again read the filament current, which should be within the limits shown on the circuit drawing or within the limits shown in Table 3 if the values are not shown on the circuit drawing. In the case of heater-type tubes, it will be necessary to wait until the current becomes stabilized. In the case of "dome"-type tubes, the filament resistance increases slightly during the first 2000 hours of operation, therefore, when new tubes are installed the filament current may initially exceed the limits specified.

Note: Failure to meet these limits will usually indicate an error in adjusting the circuit resistance due to using an incorrect type or defective resistance in the tube socket, or may very occasionally result from a defective tube.

3.22 Restore the equipment to service.

(B) Reference Current

3.23 Determination of Reference Current: The reference current should be determined for at least one filament current checking circuit connected to each distributing fuse panel. Where more than one filament current checking circuit is connected to the same fuse panel, it should be ascertained that these are so adjusted that the current readings in them do not differ by more than 0.003 ampere in the case of one-half ampere circuits or by more than 0.005 ampere in the case of one-ampere circuits, for the same battery voltage.

3.24 The reference current once determined for any filament current checking circuit should remain within 0.005 ampere in a half-ampere

circuit or within 0.010 ampere in a one-ampere circuit, as long as the mean floating voltage of the office battery is not changed or the load on the fuse panel to which the filament current checking circuit is connected remains reasonably constant.

> Note: Prior to determining the reference current, the high-low voltage alarm in the case of manually or automatically regulated batteries or the automatic voltage regulating equipment should be checked to insure that this equipment is functioning within its specified limits. This check should be made by connecting the model 1 or model 45 voltmeter across the battery at the bus bars to which the voltage alarm relay is connected and raising and lowering the voltage to the settings of the equipment. Adjustments as required should be made as covered in sections applying to this equipment.

3.25 The procedures which should be followed for the determination of the reference current are given in the following paragraphs. A 2-way talking circuit will be required between the jack appearances of the filament current checking circuit at which the test is to be made and the attendant in the power room who is assisting in the test.

3.26 Insure that the normal load is being drawn from the fuse panel to which is connected the filament current checking circuit for which the reference current is to be determined.

3.27 The cord and ammeter should be connected, with the tip to the negative terminal of the ammeter and the ring to the positive terminal of the ammeter.

> Note: On account of the wiring of the filament circuit jacks in some circuits such as HF carrier telegraph terminals, floor type carrier repeaters, VF telegraph terminals, and interference suppressors, it will be necessary to reverse the connections between the tip and ring of the cord and the meter in order for the ammeter to indicate properly.

3.28 Insert the plug of the cord to which the ammeter is connected into one of the jack appearances of the filament current checking circuit.

3.29 Note the current reading and, if necessary, adjust the resistance of the filament current checking circuit until the current is within the specified limits shown on the circuit drawing or within the limits shown in Table 3 if the values are not shown on the circuit drawing.

3.30 Have the power attendant adjust the battery voltage over its range. Read with the best possible accuracy (within 0.001 ampere) and record the current when the battery is at its high and low limit as determined by the operation of the high-low alarm in manually operated power plants, or by the operation of the automatic equipment in automatically regulated plants. Care should be taken not to override the settings of the voltage alarm or automatic voltmeter relay. In order to determine these currents accurately it may be necessary to repeat the readings several times and take the average, rejecting any extreme variations. Have the power attendant return the battery voltage to normal.

3.31 Obtain the arithmetic average of the high and low current readings recorded in Paragraph 3.30. This average is the REFERENCE CURRENT for the particular filament current checking circuit for the then normal fuse panel load. The reference current for each filament checking circuit and the serial number of the ammeter used to obtain it should be recorded in the office records for subsequent reference.

> Note: Where practicable, an adjustment of the reference current as closely as possible (within ± 0.002) to the "normal current" for the various equipment circuits as shown in Table 1, will simplify subsequent adjustment of the filament circuits.

3.32 Adjustment of Filament Circuit Resistance: If not already known, the reference current should be determined for the filament current checking circuit connected to the same distributing fuse panel to which the particular filament circuit, which is to be adjusted, is also connected. The method of doing this is described in Paragraphs 3.23 to 3.31.

3.33 Insure that the normal load is being drawn from the distributing fuse panel to which the filament current checking circuit and the filament circuit being adjusted are connected.

3.34 Remove from service the equipment associated with the filament circuit to be adjusted. (See caution following Paragraph 3.05.)

3.35 Substitute resistances for the electron tubes in the filament circuit, in accordance with the list in Paragraph 3.06.

> Note: In the case of push-pull carrier amplifiers, the filament battery in the branch of the amplifier not under test should be cut off and a tube in that amplifier branch should be removed.

3.36 Connect the ammeter and test cords to a DPDT switch in such a manner that the ammeter can be switched to either cord. The ammeter used should be the same as that used to determine the reference current. Insert the plug of one of the cords into the filament current checking circuit jack and insert the plug of the other cord into the filament jack of the circuit to be adjusted.

3.37 Read the currents in the checking circuit and the filament circuit in close succession by the operation of the switch.

3.38 Adjust the resistances in the filament circuit until the current in that circuit is the same number of milliamperes higher or lower than the current value for zero deviation from reference voltage (shown on the circuit drawing or as shown in Table 1) as the current in the filament current checking circuit is higher or lower than the reference current at any particular instant. Adjustments should be within 0.003 ampere in one-half ampere circuits and to within 0.005 ampere in one-ampere circuits of the required values.

Note: Where the filament current checking circuits are adjusted so that the reference current is exactly the same as the current value for zero deviation from reference voltage for the particular equipment under test, the filament circuits should be adjusted to the same value as the direct reading of the checking circuits. Where the current values for zero deviation from reference voltage are not shown on the circuit drawings the values shown in Table 1 may be used.

3.39 Remove the resistances from the tube sockets and reinsert the electron tubes. Again read the filament current, which should be within the limits shown on the circuit drawing or within the limits shown in Table 3. In the case of "dome"-type tubes, the filament resistance increases slightly during the first 2000 hours of operation. Therefore, when new tubes are installed the filament current may initially exceed the limits specified.

Note: Failure to meet these limits will usually indicate an error in adjusting the circuit resistance due to using an incorrect type or defective resistance in the tube sockets, or may very occasionally result from a defective tube.

3.40 Restore the equipment to service.

TABLE 1

Current Values for Zero Deviation from Reference Voltage
with Tube Replacement Resistances in the Tube Sockets
for Both "Dome"-Type and the Older Type Tubes, Not Including Heater-Type Tubes

Type of Equipment Filament Circuit	Current Values in Amperes		
	1/2 Amp.	1 Amp.	1.1 Amp.
22A1 Telephone Repeaters	0.485	0.970	
44A1 Telephone Repeaters	0.485	0.995	
11E Program Amplifiers	0.485	-	
12C Program Amplifiers	0.485	-	
14A and B Program Amplifiers	-	0.980	
1000-Cycle Ringers	0.490	-	
44A and 22A Echo Suppressors	0.485	-	
553A Echo Suppressors	0.485	0.970	
VF Telegraph Terminals	0.485	0.960	
HF Carrier Telegraph Terminals	0.485	0.970	
Carrier Teletypewriter Trunk	0.500	-	
Type C Carrier Terminals			
4-Tube Amplifier	0.485	-	
3-Tube Amplifier	0.490	-	
4-Tube Volume Limiter	0.495	-	
2-Tube Auxiliary Amplifier	-	0.980	
7-Tube Volume Limiter, F2	-	0.980	
7-Tube Volume Limiter, F1	-	0.965	
Modulator and Demodulator	0.500	0.975	
Pilot Oscillator	0.505	0.980	
Type D Carrier Terminals			
4-Tube Channel Unit	0.490	0.975	
2-Tube Amplifier	0.495	0.980	*1.115
Carrier Repeaters			
3-Tube Amplifier	0.490	-	
4-Tube Amplifier	0.485	-	
2-Tube Telephone Amplifier	-	0.980	
3-Tube Telegraph Amplifier	-	0.960	
1A Interference Suppressor			
3-Tube Amplifier	0.480	0.975	
2-Tube Rectifier	0.480	0.985	
4-Tube Rectifier	0.475	0.990	
2A Interference Suppressor			
3-Tube Amplifier	-	0.960	
4-Tube Rectifier	-	0.965	
Type C Carrier Terminals and Repeaters			
3- and 4-Tube Telephone Amplifiers	-	-	*1.110

* Use 0.960 for "dome"-type tubes.

TABLE 2

Values to Which Filament Current Should be Adjusted with Tube Replacement Resistances in the Tube Sockets, for Deviations of Measured Voltage from Reference Voltage (See Note 1) for Both "Dome"-Type and the Older Type Tubes, Not Including Heater-Type Tubes

Value of Normal Current at Zero Deviation from Reference Voltage	Deviations of Measured Voltage from Reference Voltage										
	+0.5	+0.4	+0.3	+0.2	+0.1	0	-0.1	-0.2	-0.3	-0.4	-0.5
0.475	0.486	0.484	0.481	0.479	0.477	0.475	0.473	0.471	0.469	0.466	0.464
0.480	0.491	0.489	0.486	0.484	0.482	0.480	0.478	0.476	0.474	0.471	0.469
0.485	0.496	0.494	0.491	0.489	0.487	0.485	0.483	0.481	0.479	0.476	0.474
0.490	0.501	0.499	0.496	0.494	0.492	0.490	0.488	0.486	0.484	0.481	0.479
0.495	0.506	0.504	0.501	0.499	0.497	0.495	0.493	0.491	0.489	0.486	0.484
0.500	0.511	0.509	0.506	0.504	0.502	0.500	0.498	0.496	0.494	0.491	0.489
0.505	0.516	0.514	0.511	0.509	0.507	0.505	0.503	0.501	0.499	0.496	0.494
0.960	0.982	0.977	0.973	0.969	0.964	0.960	0.956	0.951	0.947	0.943	0.938
0.965	0.987	0.982	0.978	0.974	0.969	0.965	0.961	0.956	0.952	0.948	0.943
0.970	0.992	0.987	0.983	0.979	0.974	0.970	0.966	0.961	0.957	0.953	0.948
0.975	0.997	0.992	0.988	0.984	0.979	0.975	0.971	0.966	0.962	0.958	0.953
0.980	1.002	0.997	0.993	0.989	0.984	0.980	0.976	0.971	0.967	0.963	0.958
0.985	1.007	1.002	0.998	0.994	0.989	0.985	0.981	0.976	0.972	0.968	0.963
0.990	1.012	1.007	1.003	0.999	0.994	0.990	0.986	0.981	0.977	0.973	0.968
1.030	1.052	1.047	1.043	1.039	1.034	1.030	1.026	1.021	1.017	1.013	1.008
1.110	1.135	1.130	1.125	1.120	1.115	1.110	1.105	1.100	1.095	1.090	1.085
1.115	1.140	1.135	1.130	1.125	1.120	1.115	1.110	1.105	1.100	1.095	1.090

Note 1: Adjustments should be within 0.003 ampere of these values for 0.5 ampere circuits or within 0.005 ampere of the values for 1 and 1.1 ampere circuits.

TABLE 3

Filament Current Requirements

	Old (Not Including Heater) Type Tubes	*"Dome"-Type Tubes
Half-Ampere Circuits		
Telephone Repeaters, Echo Suppressors, 1000-Cycle Ringers, VF Telegraph, 1A Interference Suppressors, 11E and 12C Program Amplifiers and HF Carrier Telegraph Terminals	0.465 to 0.505 amp.	0.460 to 0.510 amp.
Type D Carrier and Carrier Teletypewriter Trunk	0.485 to 0.525 "	0.480 to 0.530 "
Floor Type Carrier Repeaters	0.470 to 0.510 "	0.465 to 0.515 "
All Other 1/2-Ampere Carrier Circuits	0.490 to 0.530 "	0.485 to 0.535 "
One-Ampere Circuits		
Carrier Circuits, Except VF Telegraph	0.94 to 1.02 amp.	0.93 to 1.05 amp.
All Other	0.93 to 1.01 "	0.93 to 1.05 "
1.1-Ampere Circuits		
Types C and D Carrier	1.07 to 1.15 "	0.93 to 1.05 amp.

* These values apply for circuits where the use of "dome"-type tubes has been authorized.