GENERAL ELECTRIC
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DATA FOLDER No. 72131

Title: Shield Grid Characteristics of Thyratron FG-97

By

Vacuum Tube Engg. Div.

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Shield Grid Characteristics of Thyratron FG-97

Vacuum Tube Engg. Div.
Radio, Television & Electronics Dept. July 16, 1942.

Purpose

At the request of the Industrial Control Department information was obtained whereby the shield grid of the FG-97 could be used to provide additional phase and amplitude control. Two sets of control characteristics show the effect of shield voltage and shield currents upon the operation of the tube. These characteristics were also taken to 3000 volts instead of the 1000 volts peak anode voltage now used. These data should increase the scope of application of the tube and prove of value to other customers.

Procedure

Eight samples were selected at random from three different lots of tubes in stock. An effort was made to locate used tubes to determine the effect of age but none were available at the time.

Control characteristics were taken in the normal manner but with shield currents and shield voltages as additional parameters. When shield current was used as a parameter a 300-volt auxiliary d-c power source was used for the shield supply. This was applied through a high resistance (10,000 - 100,000 ohms) so that variations in shield-cathode drop would not materially affect the shield currents as the discharge point was approached, a serious difficulty when the supply was used directly.

Shield emission was checked at the end of ten minutes of operation at rated load and a shield current of 100 milliamperes, a value of shield current far beyond the range of data that could be obtained in characteristic form. It should be pointed out that obtaining shield emission by direct measurement requires the use of excellent insulation in the tube socket, switch, and the leads from the microammeter to the tube through the switch if accurate results are to be obtained. The circuit diagrams and a more detailed explanation of the difficulties attendant to the use of this method are with the original data sheets in Mr. A. C. Gable's possession.

Results

Average values and variations at a condensed mercury temperature of 40° C are listed.

Peak Arc Drop ($E_f = 2.5$ v)		15.52 v
Minimum Value	15.3 v	
Maximum Value	15.8 v	
D-c Characteristics		
100 v -2.5 v		
Maximum Value	-3.3 v*	
Minimum Value	-2.0 v	
1000 v -14.5 v		
Maximum Value	-17.5 v*	
Minimum Value	-12.8 v	
Control Grid Emission (Loss of Control Method)		0.011 ua
Maximum	0.017 ua	
Minimum	0.004 ua	
Shield Grid Emission (Direct Method)		0.19 ua
Maximum	0.35 ua	
Minimum	0.10 ua	

* Values for all tubes with the exception of one were in the -12.8 to -14 range at 1000 volts, and from -2 to -2.5 at 100 volts.

Discussion

Two sets of curves are shown whereby the shield grid may be employed to provide additional control facilities from a high impedance or a low impedance source. It is not intended that the shield be used as the only grid, but rather, as a second controlling feature in a circuit which requires two phase control circuits, or a combination of phase and magnitude control.

Shield Grid Voltage As a Parameter

When shield-to-cathode voltage is to provide the second control circuit for the tube a low resistance control source must be used. Otherwise, the change in shield current as the discharge value of control grid voltage is approached causes the shield voltage to change, resulting in erratic operation. Considerable trouble was experienced in trying to duplicate curves on the same tube before this point was noted. Furthermore, values of positive shield voltage greater than 10 volts causes the tube to break down and excessive shield currents to flow. When a-c control circuits are used sufficient series resistance should be used to limit the peak shield currents. Values of d-c in excess of +6 volts on the shield would not always permit the shield-to-cathode discharge to be extinguished after it was once started even though the anode voltage was removed.

While the negative shield voltages are very effective in controlling the tube one very interesting feature was noted. An increase in filament voltage from 2.5 to 2.6 volts caused the -6 curve of one tube to be shifted as much as 20 volts in the positive direction. Other tubes were checked and the usual shift was between 5 and 10 volts. Increase in the initial velocity of the electrons leaving the hotter filament apparently was the cause, since no such appreciable effect occurred with the shield more positive than -2 volts, a region where starting is much easier. The principal limitation of the use of the shield with negative voltages is governed by the positive control grid voltage available. D-c control grid voltages greater than +20 volts frequently maintained a continuous discharge from grid to cathode if they, too, were not removed when the anode voltage was off. Obviously, an a-c control grid source, as intended, would get around this difficulty.

<u>Shield Grid Current As a Parameter</u>

This method of control is less critical because a high value of resistance (10,000 - 100,000 ohms) in series with the shield tends to make the current dependent upon the control voltage and permits this controlling source to be of high voltage. Hence, application of these curves should be considered with control from a high impedance source. Rectification action between shield and cathode causes these characteristics to be easily applied to phase control conditions determined by a monitoring circuit. For operation at 25 and 30 mils shield current the use of the curves is limited to anode voltages of 1250 and 1000 volts respectively, since certain tubes did not readily control above this point.

The shield grid emission was taken for conditions worse than those under which the tube would normally operate and the emission is so low as to be negligible. As the tube ages it is possible for the filament coating to be sputtered onto the shield and increase the shield emission to a significant value.

The d-c characteristics at 100 and 1000 volts are so far within the published limits (+6 to -5 at 100 volts, and -6 to -20 at 1000 volts) that it is felt that a narrowing of the limits in factory inspection (+5 to -4 at 100 volts and -8 to -18 at 1000 volts) would be desirable for designers. More rigid limits could be met with practically no additional shrinkage. A check of the factory shrinkage reports shows that no tubes have been rejected on d-c characteristics in the past six months and the operators stated that they recalled only one instance when tubes were rejected for this reason, and then the entire lot failed because of a manufacturing deficiency. Prior to establishing new limits it is suggested that the factory keep a record of the exact value of each d-c characteristic test over a period of time so that limits could be established which were equitable to both engineering and manufacturing groups. Any closing in on the limits should be toward reduction of positive values, particularly at 100 volts.

While these tubes controlled at 40° C no attempt was made to find the upper temperature limit at 3000 volts. Since arcback seems to be a function of stiffness of the anode circuit the higher voltage limits must be used with discretion.

Conclusions:

1. The availability of these curves should increase the scope of application of this tube.
2. For high voltage high impedance (10,000-100,000 ohms) control sources, operation based upon variation of shield currents is recommended.
3. Control from a low voltage low impedance source is best accomplished thru use of the shield voltage curves.
4. Negative shield voltages are very effective in controlling the tube but values more negative than -2 volts are sensitive to variations in filament voltage.
5. Positive control grid voltages should be limited to + 10 volts after conduction starts.
6. Positive shield voltages above 6 volts are unsatisfactory after conduction begins. A shield voltage greater than + 10 volts will normally start conduction regardless of the control grid voltage.
7. With new tubes shield emission is a negligible factor.
8. More rigid inspection limits of the characteristics of these tubes at 100 volts is suggested. The positive limit of + 6 volts should be materially reduced. Current production tests indicate that this can be reduced to + 3 volts with no additional shrinkage. For increased use of these tubes narrower control characteristic limits are highly desirable.

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7-18-42

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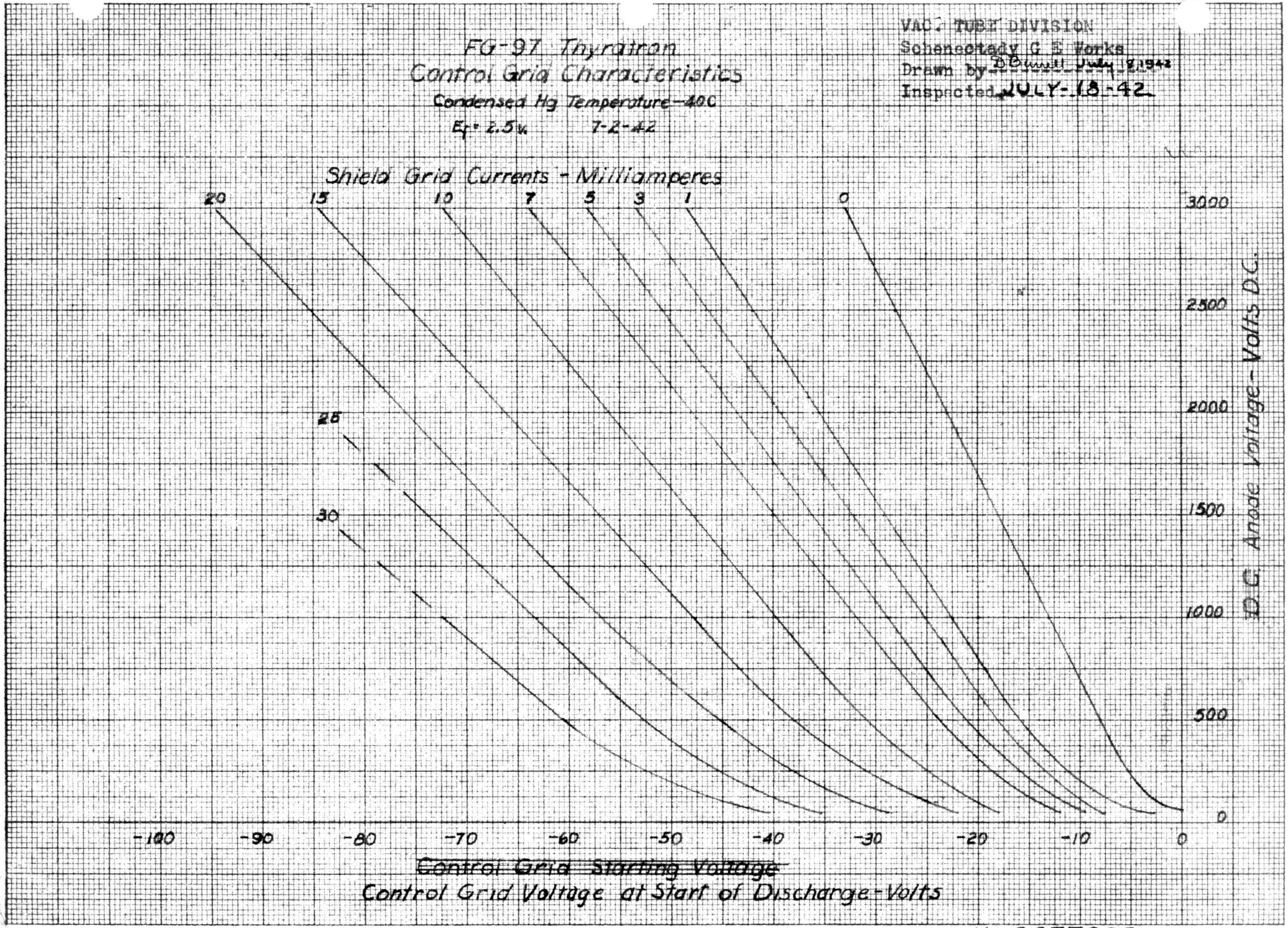

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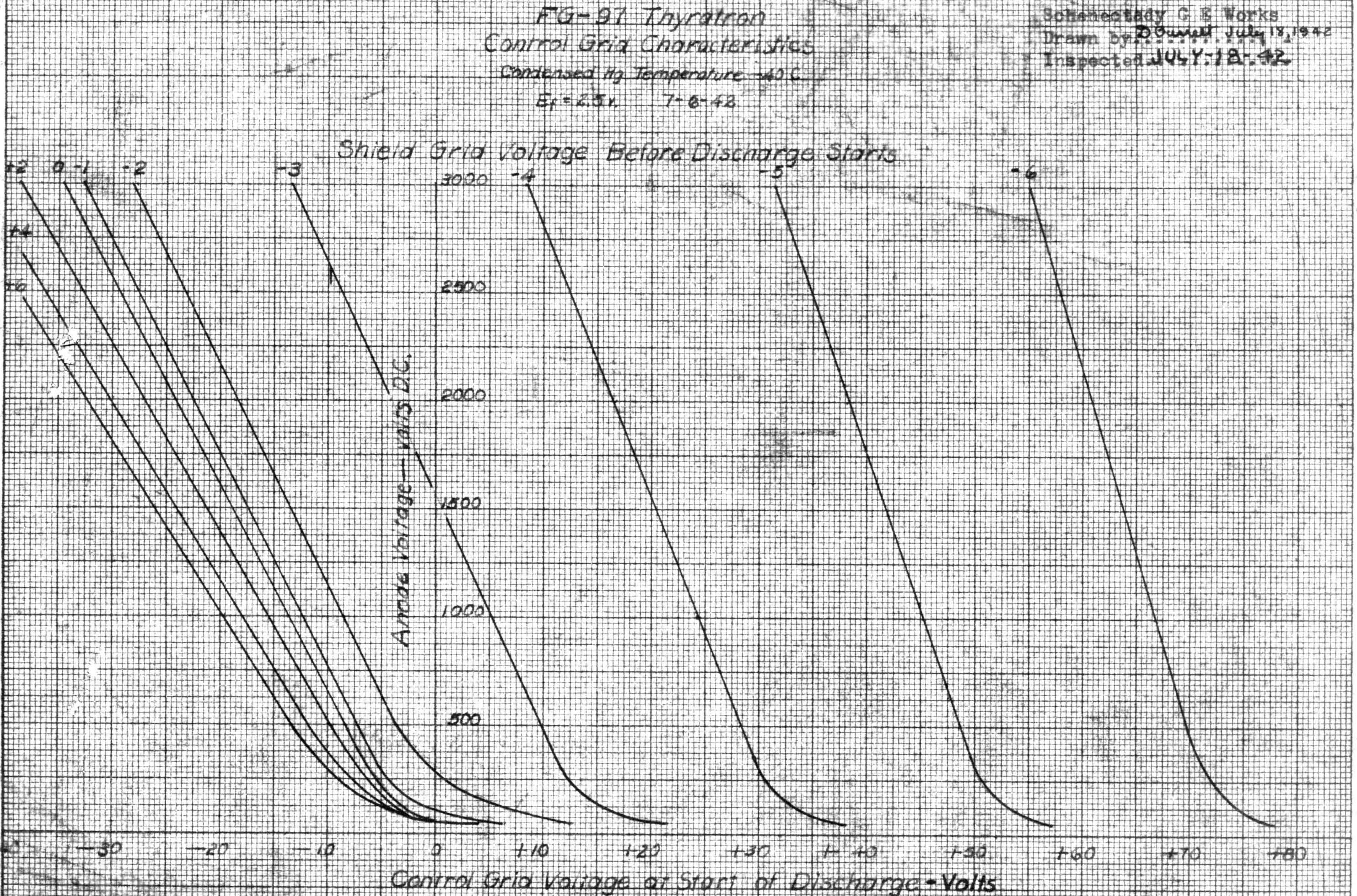

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