Abstract:
This thesis presents an investigation of negative resistance characteristics obtained from a circuit employing a pentode tube. Sources of negative resistance which are useful in communication circuits were described by Herold and others1,2,3,4. Some of them are: arc discharge, the dynatron, retarding field type of negative resistance, a space charge grid tube which operates with temperature limited cathode, the split anode magnetron and a low gas pressure triode, Thus, undoubtedly, there has been considerable research along this line but to the author's knowledge no work of investigational nature has been done on a circuit employing only a pentode tube.

The negative resistance obtained from pentode tubes does not depend on secondary emission and so the device does not have the disadvantages inherent with the dynatron mode of operation. It is found that the negative resistance obtained can be varied by: 1. Changing the amplitude of oscillation.

2. Varying the screen grid voltage.

3. Varying the control grid voltage.

4. Varying the suppressor grid voltage.

Analytical analysis has been done to derive the conditions required for a parallel tuned circuit to oscillate when connected in parallel with a negative resistance.

1. E. W. Herolds "Negative Resistance and Devices for Obtaining it", Proc.

I. R. E., vol. 23, pp. 1201-1223; October (1935).

2. C. Brunette, "The Transitron Oscillator", Proc. I. R. E., vol. 27, pp. 88-94; February (1939).

3. P. G. Sulzer, "Cathode-Coupled Negative-Resistance Circuit"; Proc; I. R. E., vol. 36, pp. 1034-1039; August (1948); 4. F. E. Terman, W. R. Hewlett, R. R. Buss, and F. C. Cahill, "Some Applications of Negative Feedlock with Particular Reference to Laboratory Equipment", Proc. I. R. E., vol. 27, pp. 649-655; October (1939).

ADJUSTABLE CONSTANT NEGATIVE RESISTANCE

by

JUGAL KISHORE GOGIA

A THESIS

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TABLE OF CONTENTS

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ABSTRACT

This thesis presents an investigation of negative resistance characteristics obtained from a circuit employing a pentode tube. Sources of negative resistance which are useful in communication circuits were described by Herold and others[1,2,3,4]. Some of them are: arc discharge, the dynatron, retarding field type of negative resistance, a space charge grid tube which operates with temperature limited cathode, the split anode magnetron and a low gas pressure triode. Thus, undoubtedly, there has been considerable research along this line but to the author's knowledge no work of investigational nature has been done on a circuit employing only a pentode tube.

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1. E. W. Herold, "Negative Resistance and Devices for Obtaining it", Proc. I. R. E., vol. 23, pp. 1201-1223; October (1935).
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INTRODUCTION

In literature dealing with electronic circuits a number of abbreviations and symbols are used which are common to the technical man. Accepted abbreviations, such as cps for cycles per second, used in radio engineering will be assumed well known to the reader. The list of symbols used in this thesis for vacuum tube voltages is included for the convenience of the reader.

A positive resistance is defined by Ohm's law as the constant of proportionality between the voltage across and current flowing through that resistance. According to Joule's law, energy will be dissipated in resistance R at the rate of P, where $P = I^2R$. Similarly, a negative resistance is defined so that Ohm's law still holds, for voltage and current will still be proportional to each other but with the difference that negative resistance will generate energy in the circuit at the rate of I^2R. Obviously, if any device is to show a negative resistance characteristic, it must contain a source of power, such as a battery, and means of controlling that power source so that Ohm's law will hold. Since in any practical case a source of power is limited, the negative resistance characteristic shown by different devices is always in a limited range.

One cause of negative resistance in high vacuum tubes is secondary emission; for example, dynatron operation. But the main disadvantage of this type of device is from its dependence upon secondary emission which changes with use of the tube. Also large differences in negative resistance may be observed in the individual tubes of the same type.

These objectionable features have been avoided by using a pentode. The negative resistance characteristic is obtained by using a circuit in which a change in screen grid voltage is accompanied by an equal change of suppressor grid voltage in the same direction. A negative voltage applied to the suppressor grid of the pentode tube repels the electrons that have passed through the screen grid and thus causes some of them to return to the screen grid. Over a certain range, a positive increment of suppressor grid voltage (a decrease of negative voltage) allows more electrons to go to the plate thus decreasing the screen grid current. Under proper operating conditions the screen grid current decreases with a positive increment of suppressor grid voltage even when the screen grid voltage is given an equal increment.

SYMBOLS FOR ELECTRODE VOLTAGES

Plate supply voltage	E_{bb}
Control grid supply voltage	E_{cc1}
Screen grid supply voltage	E_{cc2}
Suppressor grid supply voltage	E_{cc3}
Instantaneous value of alternating component of screen grid voltage	e_{g2}
Instantaneous value of alternating component of suppressor grid voltage	e_{g3}
Effective value of alternating component of screen grid voltage	E_{g2}
Effective value of alternating component of suppressor grid voltage	E_{g3}
Crest value of sinusoidal component of screen grid voltage	E_{g2m}
Crest value of sinusoidal component of suppressor grid voltage	E_{g3m}
Instantaneous total screen grid voltage	e_{c2}
Instantaneous total suppressor grid voltage	e_{c3}
Total (d.c.) voltage of suppressor grid with respect to cathode	E_{c3}

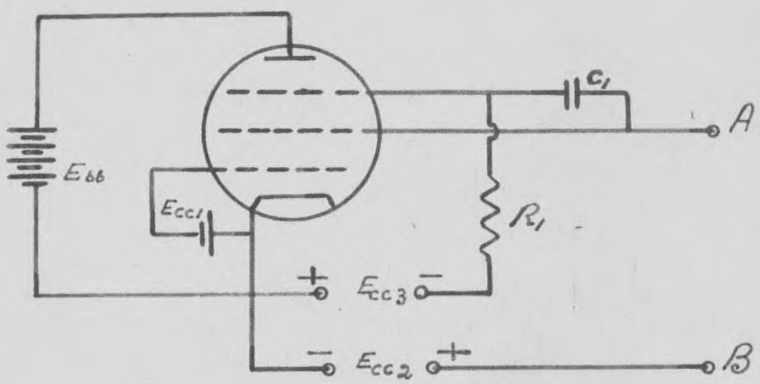
GENERAL THEORY AND OPERATION

The negative resistance is obtained from the circuit[5] shown in Fig. 1. The circuit elements C_1 and R_1 are made large enough so that a change in screen grid voltage E_{cc2} is accompanied by an equal change in suppressor grid voltage E_{cc3}. The value of negative resistance obtained from the circuit depends on d.c. voltages applied to the different electrodes and also upon the amplitude of alternating voltage applied between the terminals AB. The alternating voltage superimposed on the d.c. potential E_{cc2} applied to the screen grid changes the total instantaneous voltages e_{c2} and e_{c3} in the same direction. The d.c. potential E_{cc3} supplied to the suppressor grid is such that a positive increment in this voltage is accompanied by an equal increment in screen grid voltage. There results a decrease in screen grid current and vice versa.

If, for instance, the operating voltage E_{cc1}, E_{cc2} and E_{cc3} are 0, 100 and -11 volts, respectively, then a 6 volts increase in e_{c2} to 106 volts will be accompanied by 6 volts increase of e_{c3} to -5 volts. From Fig. 2 it is found that this produces a change in screen grid current from 17.5 milliamperes to 16.2 milliamperes. Thus an increase in screen grid voltage has resulted in decrease in screen grid current.

5. F. E. Terman, "Radio Engineers Handbook", McGraw-Hill Book Co., Inc., New York, 1943, p. 318.

Fig. 1



Tube type '837'

R_1 = 1 meg-ohm

C_1 = 0.25 μF

Typical Operation

E_{bb}	=	$46\frac{1}{2}$	volts.
E_{cc1}	=	·0	volts.
E_{cc2}	=	100	volts.
E_{cc3}	=	11	volts.

Circuit I

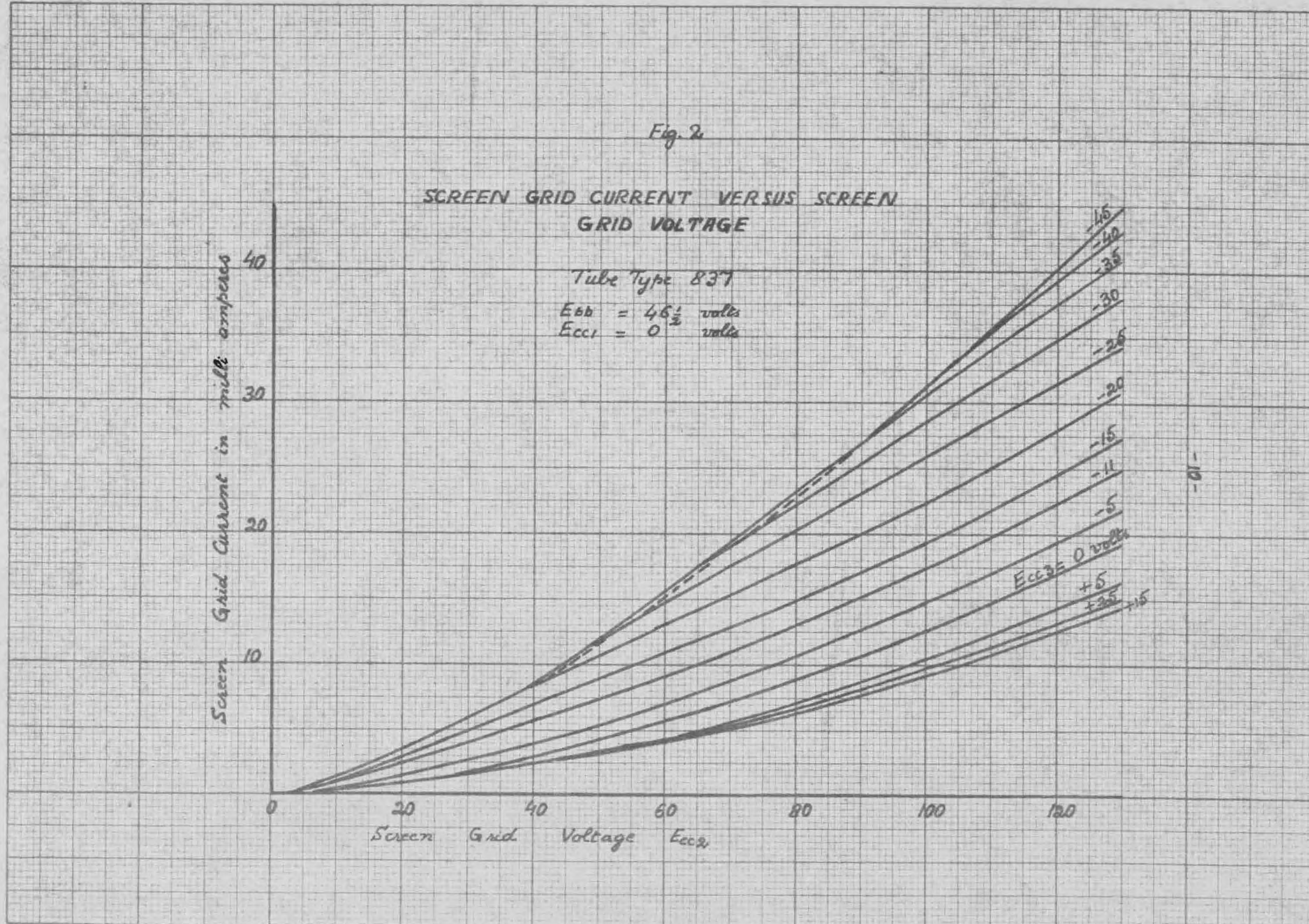


Fig. 2
SCREEN GRID CURRENT VERSUS SCREEN GRID VOLTAGE
Tube Type 837
Ebb = 46½ volts
Ecc1 = 0 volts
Screen Grid Current in milli amperes
Screen Grid Voltage Ecc2
Ecc3 = 0 volts
-45
-40
-35
-30
-25
-20
-15
-11
-5
+5
+35
+15
0
10
20
30
40
0
20
40
60
80
100
120