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Report on
Unsatisfactory Performance
of
Type 38266 Rectifier Tubes
in
Model GI Equipment

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ABSTRACT

This investigation was carried out to determine the reason for a condition of receiver interference in the key up position of the Model GI equipment when Type 38266 high vacuum tubes were substituted for Type 38166 mercury vapor tubes in the rectifier. The interference was found to be due to failure of the oscillator to stop oscillating since a small anode potential was supplied by the high vacuum rectifiers from the filament supply. A simple modification to the equipment effectively blocks the oscillator and stops the receiver interference.

AUTHORIZATION

1. This investigation was authorized by Bureau of Engineering letter, reference (a). Other references pertinent to this problem are listed as references (b) to (g) inclusive.

- Reference:
- (a) BuEng let.F42-1/38(8-1-W8) of 4 Sept.1935.
 - (b) Comdr. VP Sqdn Eight-F let.VP8F/F42-1 of 1 Aug.1935.
 - (c) Comdr. VP Sqdn Six-F let.VP6F/F42-1/A9-8 of 2 Aug.1935.
 - (d) BuEng let.F42-1(3-20-W8) of 14 Sept.1935.
 - (e) Comdr. Fleet Air Base, C.Z. let.NA10/F42-1 of 27 Aug. 1935.
 - (f) NRL let.F42-1/38 of 10 Aug.1934.
 - (g) Instruction Book for Model GI Equipment.

STATEMENT OF PROBLEM

2. Reference (a) requests the Laboratory to investigate causes of interference to radio receivers when Type 38266 high vacuum rectifiers are substituted for Type 38166 mercury vapor rectifiers in the Model GI transmitting equipment.

KNOWN FACTS BEARING ON PROBLEM

3. References (b) to (e) inclusive contain reports of this interference as experienced in the fleet. This interference consists of an audio howl in the receivers in the key up position. The frequency of the howl is approximately 1600 cycles which corresponds to the ripple frequency in the high voltage circuit. However, in the key up position no voltage is applied to the rectifier plates. The interference is most pronounced when the receiver is tuned to a frequency near the transmitter frequency and as reported in reference (e), becomes weaker as the frequency of the transmitter and receiver is increased. Reference (b) contains very helpful data regarding potentials present at various points in the high voltage circuit with the key up. This interference is present only when using the high vacuum Type 38266 tubes in the rectifier circuit.

THEORETICAL CONSIDERATIONS

4. It is rather difficult to understand why the high vacuum tubes should cause noise in the receiver when no plate voltage is applied to them. The reports of references (b) to (e) inclusive give a very good clue. The fact that the interference usually appears as a 1600 cycle audio note indicates that the 800 cycle supply is being rectified and the ripple voltage is modulating some radio frequency circuit or feeding into the audio circuit of the receiver. The fact that the interference appears strongest when the receiver is tuned to the oscillator frequency definitely indicates a modulation of the radio frequency into the receiver. Furthermore, this fact indicates that the source of trouble is in the oscillator of the transmitter. However, in the key up position the primary of the plate supply transformer is open and therefore no plate voltage should be applied to the oscillator. Reference (b) contains data which shows that a positive potential of the order of one volt is

METHODS

10. In order to investigate the conditions outlined above the Model GI equipment was set up in the Laboratory under conditions approaching as nearly as possible service conditions. Type 38266 rectifier tubes were substituted for the Type 38166 tubes. The interference to the receiver was noted and its relation to oscillator frequency determined. Readings of the voltages and currents in the various circuits were taken in the key up position with both types of rectifiers in use.

11. The center tap of the filament transformer was removed and connected to either side of the filaments of the Type 38266 tubes. This was done in order to have the positive terminal of the rectified D.C. connected directly to the cathode of the rectifiers and so eliminate the alternating potential from plate to cathode due to the filament circuit.

12. The oscillator was modified to make it cathode resistor biased instead of grid leak biased. This was done so that any time plate current flowed in the oscillator circuit a bias voltage would be produced. This modified oscillator was keyed at various speeds at various frequencies to observe its keying action.

13. The oscillator grid voltage was also determined for the two methods of obtaining bias. For grid leak bias the rectified grid current was measured as was the grid leak resistance and the voltage calculated. With the cathode resistor method the value of the cathode resistor and total current through this resistor was measured and the voltage value calculated.

DATA OBTAINED

14. The following data were obtained during this investigation.

I. Voltage at oscillator plate, key up.

Type 38266 tubes	+ 0.25 volts
Type 38166 tubes	- 6 volts

II. Oscillator grid voltage, key down

	<u>Low Power</u>	<u>Med.Power</u>	<u>High Power</u>
Grid leak bias	-184	-248	-270
Cathode resistor bias	-150	-200	-260

FACTS ESTABLISHED

15. The following facts were established.

(A) The interference experienced in the Model GI receiver when using Type 38266 high vacuum tubes in the rectifier is due to failure of the oscillator to cease oscillating in the key up position.

(B) Sufficient rectified potential is applied to the oscillator plate due to rectification of the rectifier filament supply voltage to permit oscillations in the oscillator circuit.

(C) This condition is not experienced with mercury vapor tubes since the filament voltage does not develop sufficient potential difference between anode and cathode to allow rectification to take place.

(D) Connecting the positive output terminal of the rectifier to the cathode side of the Type 38266 tube heater circuit does not improve the conditions. This is probably due to the fact that the heater is not shielded and emits sufficient electrons to produce a current flow to the rectifier plate.

(E) The only remedy for the interference is to assure complete blocking of the oscillator in the key up position. This may be accomplished by means of a cathode resistor in the oscillator circuit thereby introducing a bias on the grid at any time plate current flows through the oscillator tube.

(F) This modification to the existing Model GI equipments involves the addition of only one new part and the removal of one old part with a simple wiring change. This modification may be made as follows. The part numbers refer to the numbers found on diagram P-7760033 of ref.(g).

- (a) Disconnect the ungrounded end of resistor 3 from choke 18.
- (b) Connect the free end of choke 18 to ground.
- (c) Disconnect the black-yellow lead of the filament transformer 102 from ground.
- (d) Connect this black-yellow lead to the ungrounded and free end of resistor 3.
- (e) Replace the present 10,000 ohm resistor 3 with one of 5,000 ohms resistance. The above changes are very easily made and involve no relocation of parts. Resistor 3 is held in place by clips and is easily removed and replaced by the necessary 5,000 ohm resistor.

(G) Should any changes in the connections to the tube prongs be made, difficulty will be encountered with the present rectifier sockets in the Model GI transmitter. These sockets allow insertion of the tube in any position and have a unique criss-cross filament connection. Standard sockets would be preferable with standard wiring. Since a standard four prong wafer socket will fit the present mounting holes, this change may be made easily.

RECOMMENDATIONS

16. It is recommended:

- (a) That all Model GI transmitters be modified to provide the oscillator bias through a cathode resistor in place of the present grid leak.

(b) That tube manufacturers be consulted on the advisability of constructing the high vacuum tube in such a manner that the cathode provides a complete shield for the heater and/or providing an independent cathode terminal to one of the unused prongs on the tube base.

(c) That standard four prong wafer sockets replace the existing rectifier tube sockets and that they be so wired that the filament supply is connected only to the filament prongs of the tube.

SUMMARY AND DISCUSSION

17. The interference is due to the fact that the oscillator does not stop oscillating when Type 38266 tubes are used in the power supply. The filament heating potential supplies an alternating voltage which is rectified and supplied to the oscillator plate in the key up position. This effect is due to the fact that the cathode is changing potential with respect to the plate and the high vacuum tubes will conduct at any time a potential difference of the right polarity exists between anode and cathode. This is not true of the mercury vapor type tubes and no interference is apparent in the key up position when they are used.

18. Attempts to maintain the cathode at anode potential in the key up position by connecting the cathode directly to the positive output terminal of the rectifier were unsuccessful. This is probably due to the fact the cathode does not completely shield the heater inside the tube which allows the heater itself to emit electrons and cause a current flow through the rectifier tube. It must be remembered that the cathode is connected internally to one side of the heater circuit.

19. Since the interference stops when the oscillator ceases to oscillate, the obvious remedy is to provide means for stopping the oscillator in the key up position. Ref.(b) suggests breaking the plate supply to the oscillator. This would entail a modification of the keying relay and a considerable amount of rewiring. A more simple method seemed to be by applying a slight negative voltage to the grid at any time the plate of the oscillator became positive. This may be accomplished by inserting a resistance between the cathode and ground and grounding the grid return. Thus the grid has a bias voltage applied to it at any time plate current flows regardless of this current value. A 5,000 ohm cathode resistor was found to effectively block the oscillator in the key up position when using Type 38266 tubes in the rectifier circuit.

20. Measurements of the grid voltage before and after modifying the biasing system show that the 5,000 ohm cathode resistor is satisfactory under all operating conditions. The results of these measurements are shown in Table II under DATA. It will be noted that the grid voltage with the cathode resistor method of biasing is slightly lower than with the grid leak. This is proper since the effective plate voltage is also somewhat lower when using the cathode resistor. Tests made of power output and keying show this method to be entirely satisfactory. This modification allows the transmitter to work equally well with both types of rectifiers.