High altitude tests and modifications on AN/APX-6 IFF transponders

Riordon, J. S.

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HIGH ALTITUDE TESTS AND MODIFICATIONS ON AN/APX-6 IFF TRANSPONDERS

J. S. RIORDON

OTTAWA
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ABSTRACT

A request was received by the National Research Council from the Royal Canadian Air Force to investigate the cause of failure of the AN/APX-6 airborne IFF transponder at altitudes above 35,000 feet. Five transponders were subjected to vacuum chamber tests which showed that electrical breakdown occurred both in the transmitter cavity and between high voltage leads. The transponder was made operational to a height of 50,000 feet by means of a slight decrease in transmitter pulse voltage and a rearrangement of the high voltage wiring. Its operation in flight trials appeared satisfactory.

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HIGH ALTITUDE TESTS AND MODIFICATIONS ON AN/APX-6 IFF TRANSPONDERS

- J.S. Riordon -

INTRODUCTION

A request was received by the National Research Council from the Royal Canadian Air Force to investigate the cause of failure of the AN/APX-6 airborne IFF transponder at high altitudes. The set was originally designed for use at about 35,000 feet. The ceiling of the present CF-100 aircraft is somewhat above this limit, and a considerable number of IFF failures had been experienced. In some of these cases, replies to interrogation signals were again received after the aircraft dropped below the critical level, while in others the transponder remained inactive for the duration of the flight and on inspection a fuse was found to have melted. The RCAF wished to have modifications made to allow operation at higher altitudes — 50,000 feet or more.

TESTS

Vacuum chamber tests were carried out on five RT 82 transponders (serial nos. 82, 01183, 01402, 01590, and 01847). It was determined that two types of failure occurred at high altitudes:

1) arcing in the transmitter cavity;

2) melting of the a-c line fuse F-101 and/or the high voltage fuse F-105.

The first type of failure above disappears when the set is brought down below the critical altitude (43,000 - 48,000 feet indicated altitudes for the sets tested). In the second case, of course, the set does not resume operation. In order to determine the cause of the latter failure, three of the sets were allowed to run with fuses of higher current rating. In each case the high voltage supply wiring insulation was broken down by arcing (at altitudes of 43,000, 52,000, and 56,000 feet). Two points of breakdown are shown in Figs. 1 and 2. It is worth noting that each breakdown took place at a different point in the circuit. Tests carried out at 60 cycles on a sample of the high voltage supply wire showed that a single layer of the insulation breaks down at 32 kilovolts r.m.s. at atmospheric pressure. As this type of insulation breaks down at 1050 volts d-c at a height of about 50,000 feet, it is probably rather porous, and obviously unsuitable.

MODIFICATIONS

a) Transmitter Cavity

Three possible modifications may be made to remedy cavity arcing:

1) pressurizing the cavity;

2) insulating the surfaces between which breakdown occurs;

3) lowering the pulse voltage.

Each of these methods was considered. Pressurization is a basic design modification, requiring a considerable change in layout, and was discarded because of the expense and effort involved. It has, however, been incorporated by the manufacturer in the newest model of the transponder, the RT-279A.

Teflon sheet insulation of several thicknesses was placed on the surface immediately adjacent to the feedback capacitor C-404 in the transmitter cavity. Three sheets of 0.005" teflon (i.e., a total insulation thickness of 0.015") proved moderately effective. However, two objections ruled this out: first, the dielectric is not self-healing, and consequently loses its effectiveness after several breakdowns; second, it causes a rather high signal power loss (5 to 6 db for three sheets).

The third method, that of lowering the transmitter pulse voltage, was found to be simple, yet effective. A resistor was placed between the plate of the modulator tube, V-111, and terminal 1 of the modulation transformer, T-103 (see Fig. 3). Vacuum chamber tests were carried out on all five transponders. The modulation pulse was monitored at test point 4-6 (see Fig. 3); in each case breakdown altitude, power loss, and resistance value were recorded. Fig. 4 is a plot of the result for three of the sets. On the basis of these results, it was decided to use a 100-ohm 2-watt ± 5% resistor in the sets held at NRC, and to subject these to flight trials. Although only three sets were tested in the chamber, it seems reasonable to assume that a resistor of this value will reduce to an acceptable degree the probability of cavity breakdown at altitudes of approximately 50,000 feet, and at the same time will not cause a serious drop in power output. It is clear as well that a higher resistance value will cause excessive power loss, will give a greater altitude capability, and in these sets will bring the operation near a point where some other limiting factor is applicable.

b) <u>High Voltage Wiring</u>

This is a problem of both insulation and lead dress, as may be seen from Figs. 1 and 2. To remedy it, all wiring at potentials above 600 volts was replaced with wire whose insulation rating was 12 kilovolts d-c. (This insulation was actually tested to 50 kilovolts r.m.s. without breakdown.) This wiring was placed so as to avoid positions likely to cause arcing; in addition, rubber boots were placed over critical terminals. These changes are shown in Figs. 5 and 6.

It should be noted that while all the sets tested were of the RT-82 type, the same modifications apply equally to the newer RT-279, but not to the RT-279A.

RESULTS

The sets modified were found to operate in a vacuum chamber at a pressure corresponding to an altitude of 50, 000 feet with a loss of about 1 db in radio frequency power. At greater heights arcing tended to occur, but in no case did a fuse melt. The maximum test height was 57, 000 feet in the pressure chamber. It is suggested that the wiring changes outlined in the Appendix to this report be carried out on all equipments to be flown over 35, 000 feet and that a 100-ohm resistor be used to lower the cavity voltages. It is expected that such changes will provide reasonably trouble-free operation to heights equivalent to the pressure chamber indicated altitude of 50, 000 feet. At altitudes near this level (above or below) individual set characteristics will control the probability of breakdown and this may well vary from day to day.

Flight trials were carried out by the RCAF in December 1957. It is understood that operation was generally satisfactory, and that the anticipated slight loss of range was observed only with difficulty and is not of operational significance.

ACKNOWLEDGMENTS

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APPENDIX

INSTRUCTIONS FOR MODIFICATION OF AN/APX-6 RT 82 AND RT 279

NOTE: It is essential to keep all wires as short as possible, and to ensure that no wire, even where insulated, touches any terminal other than its own. Soldering should be done especially carefully; a blob of solder projecting from a terminal can cause a flashover.

1. MODIFICATION OF REAR PANEL ASSEMBLY

a) Remove rear cover and high voltage protecting cover.

b) Remove high voltage wire between pin 1 of X-119 and pin 1 of X-120 and replace with a short straight piece of the high voltage wire supplied for the modification.

c) Repeat the above operation on the following high voltage wires:

   i) from pin 4 of X-119 to pin 4 of X-120
   ii) from R-242 to R-243
   iii) from terminal 13 of T-104 to left side of H.V. fuse F-105
   iv) from terminal 1 of L-101 to terminal 1 of C-241
   v) from terminal 1 of L-101 to terminal 2 of T-103
   vi) from R-252 to R-253

NOTE 1: In steps d and e, the cable clamps should be attached underneath the Bakelite strip, and not above it as in Fig. 5. This is to ensure that the rear cover of the transponder will fit properly.

d) Remove wire from terminal 2 of L-101 to right side of high voltage fuse F-105, and replace with new wire, clamping it on right post of resistor assembly (see Note 1 above).

e) Repeat with wire from pin 1 of X-119 to terminal 14 of T-104, clamping it on left post of resistor assembly (see Note 1 above).

f) Remove wire from pin 4 of X-119 to terminal 13 of T-104, and replace with one from pin 4 of X-119 to left side of fuse F-105, as shown in Fig. 5.

g) Remove from cable wire joining pin 4 of V-118 to terminal 4 of transformer T-104, and replace with a high voltage wire running directly between the two, putting a rubber boot over terminal 4. Repeat with wire from pin 6 of V-118 to terminal 8 of T-104, putting a boot over terminal 8.

NOTE 2: A standoff terminal is shown near terminal 8 in Fig. 5. However, a rubber boot placed over terminal 8 is equally satisfactory, and quicker to install; it is therefore recommended instead of the standoff terminal shown.

h) Remove from cable wire joining R-247 to right hand terminal of C-251, and join directly, as shown in Fig. 5, using high voltage wiring.

i) Flatten projecting part of pin 5 of V-118 (5Y3GT/G). Open front panel of transponder, and remove tube V-118. Push pin 5 in through rear of chassis, and remove this pin through the front; replace tube.

j) Check all steps, and replace rear covers.

2. MODIFICATION OF FRONT PANEL ASSEMBLY

a) Open front panel of transponder.

b) Remove porcelain insulators from rods.

c) Remove wires from plate of V-119 to terminal 15 of T-104 and from plate of V-120 to terminal 16. Replace these with short pieces of high voltage wire, and place rubber boots over terminals 15 and 16. See Fig. 6.

d) Remove wire from plate of V-111 to terminal 1 of T-103, and replace with a 100-ohm 2-watt ± 5% resistor, as shown in Fig. 6.

NOTE 3: Although adequate for trial purposes, the method shown in Fig. 6 is not recommended for service use since vibration may cause failure. An under-chassis mounting in the high voltage lead to terminal 2 of T-103 should be investigated.

e) Replace porcelain insulators; check all steps.

f) Close front panel.

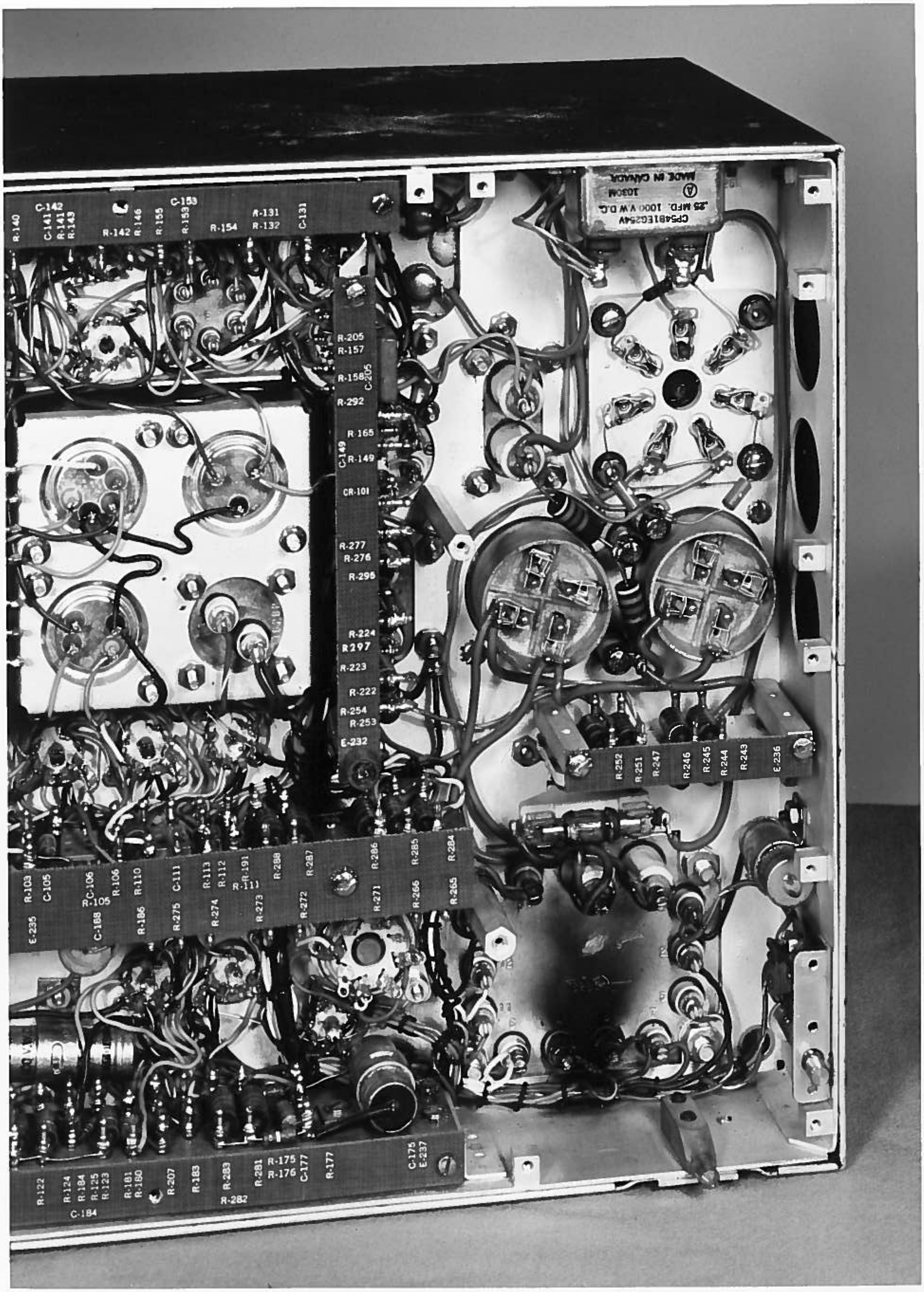

FIG. 1. INSULATION BREAKDOWN BETWEEN TERMINALS 4 AND 8 OF POWER SUPPLY TRANSFORMER

FIG. 2. INSULATION BREAKDOWN BETWEEN TERMINALS 15 AND 16
OF POWER SUPPLY TRANSFORMER

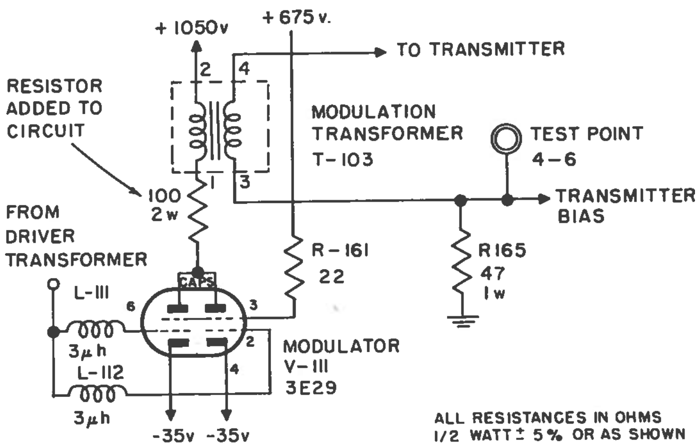

FIG. 3. MODIFIED CIRCUIT OF TRANSMITTER MODULATOR

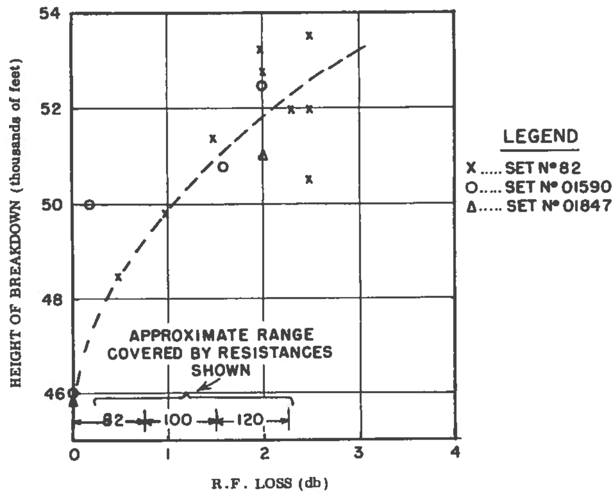

FIG. 4. EFFECT OF MODULATOR PLATE RESISTANCE ON BREAKDOWN HEIGHT AND POWER OUTPUT

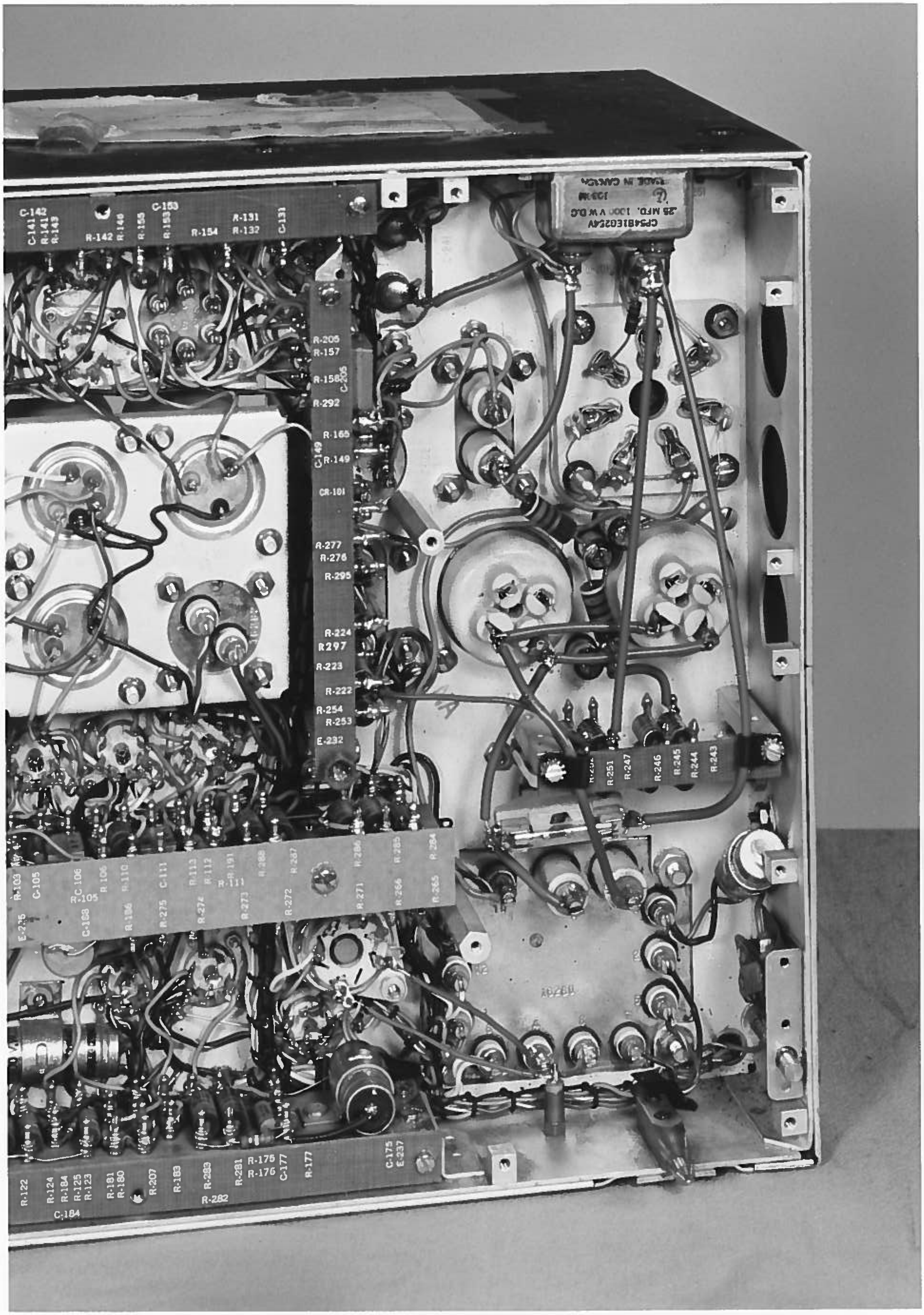

FIG. 5. REVISED LAYOUT OF HIGH VOLTAGE WIRING (rear of chassis)

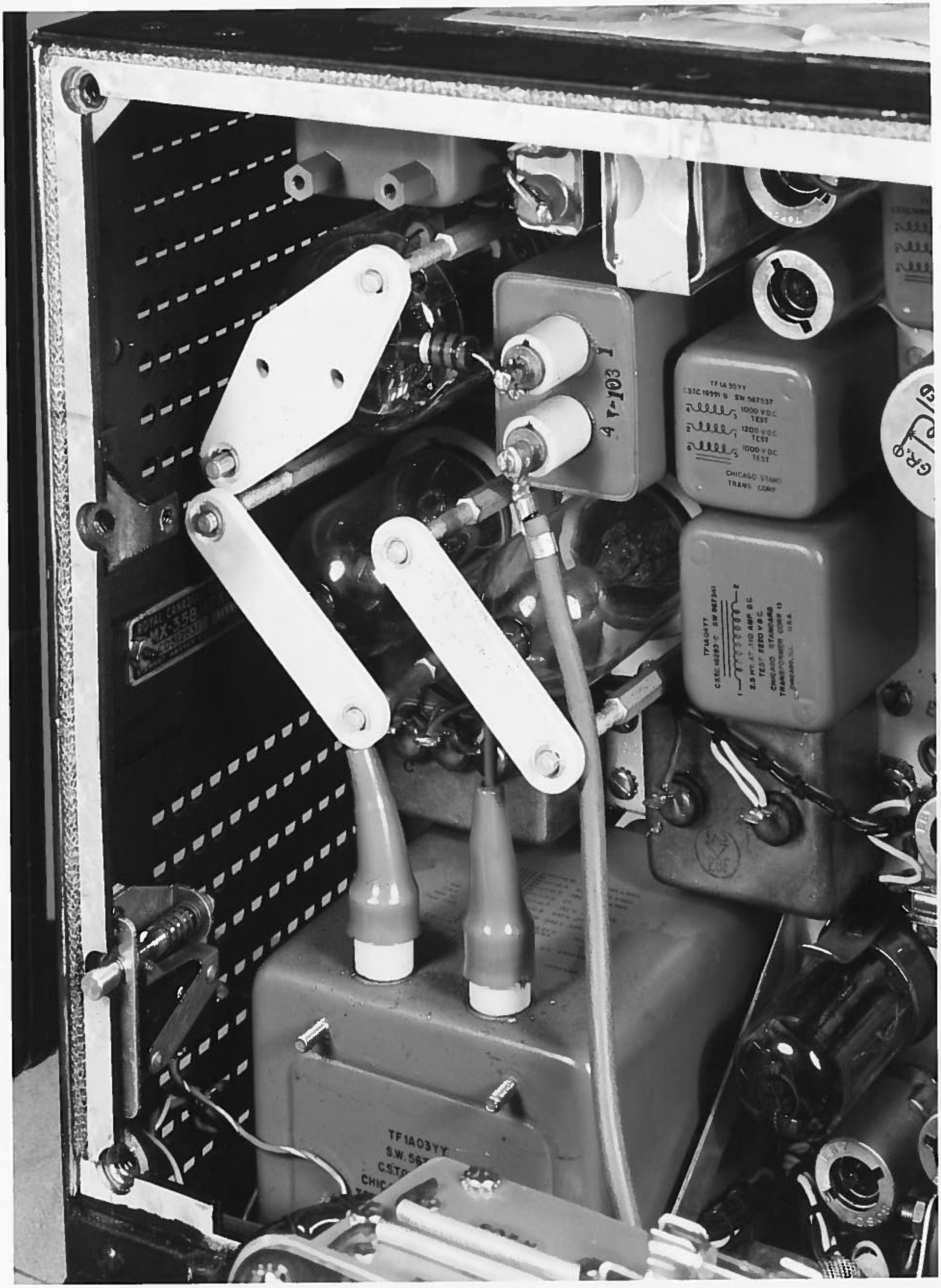

FIG. 6. REVISED LAYOUT OF HIGH VOLTAGE WIRING (front of chassis) WITH 100-OHM RESISTOR INSTALLED