ELECTRON TUBES

RCA Application Note

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# RCA "Special Red" Tubes for Industrial Applications

Electron tubes of the receiving class are finding increasing use in applications broadly classified as "industrial". These applications occur in many varieties of control circuits such as control circuits for temperature regulation, control circuits for the starting, stopping, and speed regulation of motors, and control circuits for lighting equipment. Other applications are found in computing machinery, in measuring equipment, and in counting and sorting devices. Many of the uses of electron tubes in communications, including broadcasting, should be included. Another group of applications includes railway signalling equipment, navigation equipment, devices for overload and overspeed protection, and devices for the protection of machine operators.

Broadly speaking, industrial applications can be considered to include all types of equipment in which the primary considerations of design and use are revenue or safety. The requirement of revenue or safety takes in applications such as those listed above, but generally excludes the use of tubes in home receivers or in toys. In a typical industrial application uninterrupted tube performance is necessary for the preparation of a product, or the maintenance of quality, or (as in broadcasting) the maintenance of a service from which revenue is obtained. The unexpected failure of a tube in industrial service can frequently result in a monetary loss far greater than the initial cost of the tube itself. However, the failure of a tube in a home receiver generally is only a matter of inconvenience and the cost is no more than the tube replacement cost.

RCA has recently announced three new tubes, RCA-5691, RCA-5692, and RCA-5693, called RCA Special Red tubes, which have been developed to meet the demands of industrial applications. It is the purpose of this Note to describe the many special features incorporated in the design and manufacture of these tubes and to discuss the significance and importance of these features in critical industrial applications where reliability, ruggedness, and long life are essential.



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## Performance Features

These three types are very similiar in electrical characteristics to three popular types used in receiving and other equipment. Type 5691 is a high-mu twin triode, similar in characteristics to type 6SL7-GT except for the amount of heater current required. Type 5692 is a medium-mu twin triode similar to type 6SN7-GT, and type 5693 is a sharp-cutoff pentode similar to type 6SJ7. The basing connections for types 5691, 5692, and 5693 correspond to those for types 6SL7-GT, 6SN7-GT, and 6SJ7, respectively, so substitutions may be made when operating conditions are within the ratings of the Special Red tubes and the service requirements are such as to justify their use. The higher heater current, of course, must be taken into account when the substitution of type 5691 for type 6SL7-GT is considered.

Long life for the Special Red tubes is assured by the choice and inspection of the materials used in tubes, by the use of careful processing and assembling, and by conservative ratings which provide for moderate current per unit area from the cathode and for moderate power dissipation per unit area for the plates and grids. Pure tungsten wire is used in preference to alloy wire for the heaters because tungsten wire has greater strength. Nickel tubing is used around the heater wires at the weld junctions to the stem wires to secure a stronger weld and thus to prevent breakage or burnouts at these points particularly under conditions of frequent "on-off" switching. The heaters for the separate units for the twin-triode types, 5691 and 5692, are connected in series; this arrangement permits the use of heavier heater wire. In addition, series connection of the heaters in twin-unit types is preferred in many industrial applications because "fail-safe" considerations make it desirable that a heater burnout render both sections inoperative simultaneously. When Special Red tubes are operated within ratings, their average life should be well in excess of ten thousand hours. This figure represents about fourteen months of continuous round-the-clock service. Long life is especially important in devices or systems using a large number of tubes and in cases where the replacement of a tube presents unusual difficulty or expense.

Uniformity and stability of characteristics for an individual tube during its life and among tubes of a given type are very important in industrial applications. Uniformity among tubes is achieved by great care in the selection and inspection of materials, gauging of parts, and inspection and testing of the tube assemblies before they are sealed in their enclosures. In addition, numerous tests are made on the finished tubes and the limits employed are much closer than for other tubes. The Special Red tubes are seasoned for a long period before final testing. This processing minimizes changes in characteristics during operation which would result from variations in contact potential and exposes an excessive changes in characteristics which would be indicative of premature failure. The precautions taken to insure uniformity and stability lead to exceptionally good balance between sections in the twin-triode types, 5691 and 5692. They may, therefore, be used without balancing adjustments in many applications. In more critical applications, the range required for balancing controls is minimized and the balance obtained by adjustment is maintained for long periods.

Ruggedness is achieved, primarily, by the use of rigid structures. This feature is important because industrial applications include some in which vibration is difficult to avoid and in which the tubes may have to operate under severe impact conditions.

## Structural Features

Fig. 1 shows the construction used for type 5693. For this type, an all-steel A-frame structure (15) is used to support the electrode assembly. The A-frame support is welded directly to a steel ring; a glass button (1) sealed inside this ring carries the leads connecting the electrodes to the base.

Figs. 2 and 3 show the construction used for types 5691 and 5692. The electrode assembly is held together by five supporting rods (13) welded to eyelets (14) in the top and bottom mica insulators. A third mica disk (9) is supported by two of these rods; this disk prevents the material evaporated from the two getters (10) from reaching the electrodes. The electrode assembly is supported by eight lead wires in a button-type stem (1). The total support given by the lead wires is very rigid, although the individual wires are soft enough to prevent excessive stress in the glass seal.

Some of the features common to all three Special Red types are:

1. The cathode has an embossed ring (5) near its upper end. This ring is pressed against the lower side of the upper mica insulator and the part of the cathode sleeve extending above the mica is then squeezed and welded to clamp the cathode sleeve in position. A very close fit between the cathode sleeve and the holes in the mica insulators is maintained. The effectiveness of this method of assembly in reducing variations in characteristics under vibration and shock conditions has been proven in many RCA types where stability of characteristics and low microphonics are necessary.

2. The supporting wires for the grids are provided with metal stops (7) to prevent the distortion of the fine grid wires which could result from vertical displacement of the supporting wires in the mica insulators.

3. The fit between the grid support wires (8) and the holes in the mica insulators is so close that some pressure is required to force the support wires through the insulators. As a consequence, more time is required by an operator to put a tube together, but the tube is sturdier and much harder to shake apart.

4. The red bases used on the Special Red tubes are made of materials which insure low moisture absorption and very high resistance between terminals under high-humidity conditions. The bases are molded with barriers between the pins to reduce leakage even further.

## Quality Control

All of the Special Red tubes are tested during manufacture under vibration to detect any looseness which might cause premature failure.

# RCA "Special"

## FEATURES

1—Low-leakage button stem.
2—Non-hygroscopic base.
3—Pure-tungsten heater for high mechanical strength.
4—Sleeves on heater legs insure good mechanical and electrical bond between heater and heater leads.
5—Cathode sleeves locked to mica insulator.
6—Grid plated to minimize variation in contact potential.
7—"Stops" prevent vertical movement of grid rods.
8—Grid rods fit tightly into mica insulators.
9—Extra mica insulator provides getter shield.
10—Two getters for long life.
11—Plates held rigid by plate ears wedged into mica insulators.
12—Plates are designed to minimize electron coupling between units.
13—Mount secured by five supporting rods.
14—Twelve reinforcing eyelets provide a firm bond between mica insulators and five supporting rods.
15—Integral "A-Frame" for strength.

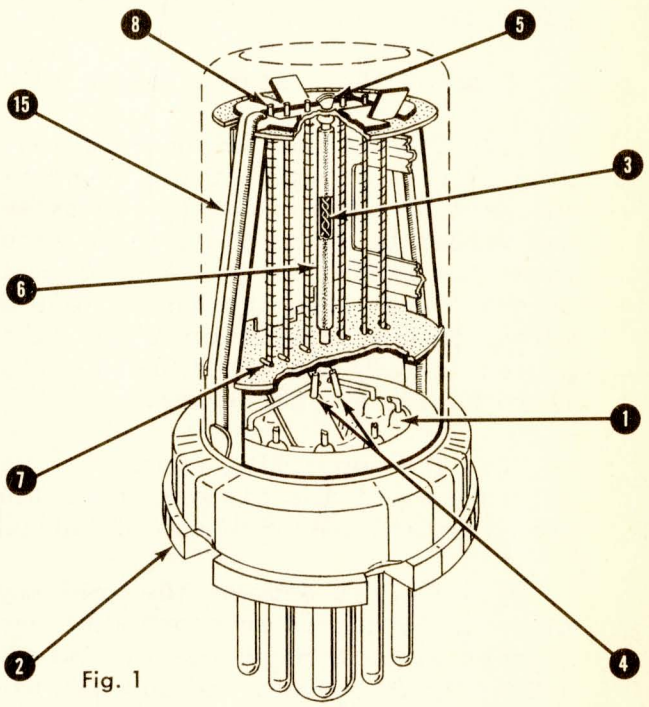


Fig. 1

**Structural Details of RCA-5693, Sharp-Cutoff Pentode**

# Red " TUBES

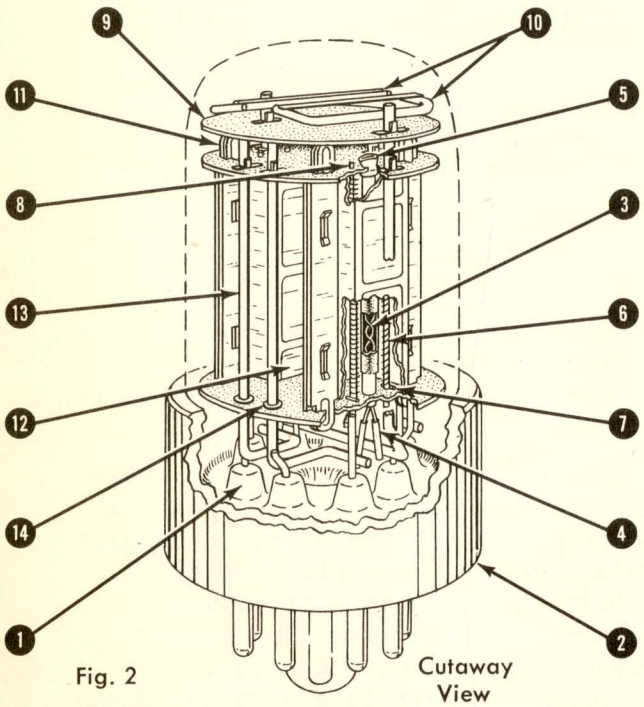



Fig. 2 Cutaway View

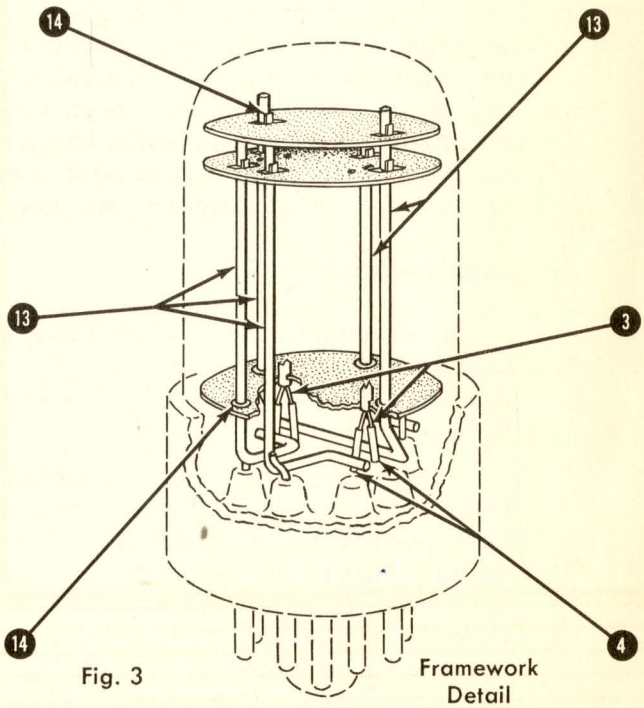



Fig. 3 Framework Detail

## Structural Details of RCA-5691 and RCA-5692, Twin-Triodes

Life-test data show that the tubes are capable of withstanding for hundreds of hours with less than 10% change in important characteristics continuous vibration at 20 cycles per second and 2.5 g acceleration with full voltages applied. Shock tests with impact accelerations as high as 500 g have been made on the Special Red tubes. These tests indicate that the tubes can withstand impact shocks of 100 g for extended periods and impact shocks of 500 g for periods.

The plate current versus grid-No.1 voltage characteristic of type 5693 is checked against both maximum and minimum limits at a control-grid bias approaching cutoff as well as at a typical operating condition. The plate current versus grid-No.3 voltage characteristic for this type is also checked to insure uniformity of performance in applications for which this characteristic is important.

Types 5691 and 5692 are tested for balance between sections in order to exclude the possibility of both maximum and minimum values of allowable plate current occurring in the two units of the same tube.

The grid current limits used in testing the Special Red tubes are of particular interest. The maximum allowable signal-grid current for type 5693 under the test operating conditions is 0.10 microampere; this current would produce a shift in voltage of only 0.5 volt when a grid resistor of 5 megohms is used. Grid resistors of higher value (Fig.4) may be used when the circuit employed includes either bias from a cathode resistor or a series resistor in the screen circuit. The grid currents allowed under test operating conditions for types 5691 and 5692 do not exceed 0.20 microampere per tube.

## Applications

The Special Red tubes are, in general, intended for use in the same manner and in the same circuits as their receiving-type counterparts. The applications suggested below point up some of the features of these tubes.

Type 5693 can be recommended as a high-gain audio-frequency amplifier, or a dc amplifier, particularly when the source of input signal is a phototube, a crystal, or a similar high-impedance source. The low value of grid current and the low-leakage non-hygroscopic base are features which are particularly important for this type of service. When type 5693 is used as a dc amplifier, the stabilization of contact potential obtained by seasoning becomes an important advantage. Use of the suppressor grid as an additional control electrode can be recommended for type 5693 because the suppressor characteristic of this type is held within specified limits.

Types 5691 and 5692 are useful as audio amplifiers or as dc amplifiers and have the same advantage over receiving-type tubes as type 5693. The Special Red twin triodes can be particularly recommended for applications in which good balance between the two sections is required. In addition, other features of these tubes make them desirable for multivibrators, cascaded amplifiers, and for other applications in which uniformity, reliability, and extremely long life are essential.

$E_f$ = 6.3 VOLTS  PLATE VOLTS = 300  GRID-№ 3 VOLTS = 0

| CURVE | GRID-№2 RESISTOR | GRID-№ 2 SUPPLY VOLTS |
|---|---|---|
| 1 | 0 MEG. | 100 |
| 2 | 0.25 MEG. | 300 |
| 3 | 0.5 MEG. | 300 |
| 4 | 0.75 MEG. | 300 |

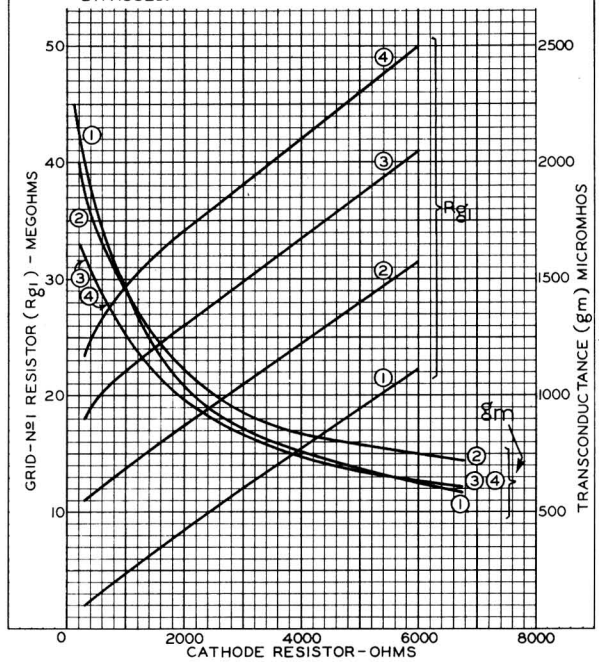
THESE CURVES ARE BASED ON THE FOLLOWING VALUES: $\Delta I_K$=300μAMP, $\Delta Ig_1$ = 0.1μAMP

EXPRESSING THESE VALUES AS A RATIO, WE HAVE:

$$\frac{\Delta I_K}{\Delta Ig_1} = \frac{300}{0.1} \text{ OR } 3000$$

FOR THOSE APPLICATIONS PERMITTING OTHER VALUES OF $\Delta I_K$, A NEW RATIO OF $\Delta I_K/\Delta Ig_1$ CAN BE CALCULATED. THE VALUES OF $Rg_1$ AS READ FROM THE CURVE MUST BE MULTIPLIED BY A FACTOR WHICH IS THE QUOTIENT OF THE NEW RATIO DIVIDED BY THE OLD RATIO. FOR EXAMPLE, IF THE NEW RATIO IS 6000 THE MULTIPLYING FACTOR IS 6000/3000, OR 2, AND VALUES OF $Rg_1$ AS READ FROM THE CURVE ARE THEREFORE MULTIPLIED BY 2.

NOTE: TRANSCONDUCTANCE CURVES WERE OBTAINED WITH GRID-№2 RESISTOR AND CATHODE RESISTOR SUITABLY BYPASSED.




92CM-6920

*Fig. 4 - Operation Characteristics of Type 5693.*

# RCA

# *Special Red* TUBES


## The 10,000-Hour Line

**RCA "Special Red" Tubes will be replaced if they fail within 10,000 hours of life, or within two years after initial use (whichever occurs first) when operated within our published maximum ratings. Claims for adjustment will be considered only if presented within 30 months after shipment from our Warehouse.**