RCA Application Note

AN-171

Anodized Aluminum or Mica Washers for Insulated Mounting of RCA-2N301 and 2N301-A Transistors

This Note describes a method for mounting RCA-2N301 and RCA-2N301-A power transistors which provides electrical insulation of the collector electrode from the chassis without appreciable reduction in heat-transfer efficiency. This method makes use of anodized aluminum insulating washers or thin mica washers having relatively high thermal conductivity between the mounting flange and chassis and, therefore, permits these transistors to be operated at relatively high power dissipations in class B push-pull amplifier service and in applications where the chassis is connected to the positive terminal of the voltage supply.

Transistor Heat-Dissipation Considerations

The 2N301 and 2N301-A are alloy-junction power transistors of the germanium p-n-p type designed specifically for use in class A or push-pull class B power-amplifier service in automobile radio receivers and military and commercial communications equipment. As shown in Table I, the maximum power-dissipation ratings for these transistors vary with the temperature of the mounting flange, which is connected internally to the collector electrode. Because the collector should be maintained at the lowest practicable temperature, it is usually desirable to connect the mounting flange directly to a good "heat sink" (generally the chassis) so that heat generated at the collector junction will flow to the heat sink and be dissipated to the surrounding air.

In some circuits, however, particularly push-pull arrangements and those in which the chassis is connected to the positive terminal of the voltage supply, the collector must be electrically insulated from the chassis. If the maximum power capabilities of the 2N301 and 2N301-A are to be utilized in such circuits, this insulation must be accomplished without appreciable reduction of heat-transfer efficiency. An anodized aluminum or mica washer placed between the mounting flange and the chassis has the necessary heat-transfer efficiency and, at the same time, provides the required electrical insulation. In the case of the aluminum washer, the anodizing process coats the washer with aluminum oxide so that it becomes a good electrical insulator without losing its high thermal conductivity.

SEMICONDUCTOR DIVISION
RADIO CORPORATION OF AMERICA, SOMERVILLE, NEW JERSEY

6/57
Printed
in U.S.A.

Table I - Maximum Ratings for 2N301 and 2N301-A Power Transistors.

AUDIO-FREQUENCY POWER AMPLIFIER--Class A and Class B

Maximum Ratings, *Absolute Values:*	*2N301*	*2N301-A*	
PEAK COLLECTOR-TO-BASE VOLTAGE	-40 max	-60 max	volts
DC COLLECTOR-TO-BASE VOLTAGE (For inductive load)	-20 max	-30 max	volts
DC EMITTER-TO-BASE VOLTAGE	-12 max	-12 max	volts
PEAK COLLECTOR CURRENT	-2 max	-2 max	amperes
DC COLLECTOR CURRENT	-1 max	-1 max	ampere
PEAK EMITTER CURRENT	2 max	2 max	amperes
DC EMITTER CURRENT	1 max	1 max	ampere
TRANSISTOR DISSIPATION:			
*For Continuous Operation:**			
For mounting-flange temperatures up to 55°C	12 max	12 max	watts
For mounting-flange temperature of 71°C.	5.5 max	5.5 max	watts
For Intermittent Operation:●			
For mounting-flange temperature of 80°C.	7.5 max	7.5 max	watts
MOUNTING-FLANGE TEMPERATURE (During operation)	85 max	85 max	°C
STORAGE-TEMPERATURE RANGE	-65 to +85	-65 to +85	°C

* The maximum transistor-dissipation rating is reduced 0.4 watt for each degree centigrade the mounting-flange temperature is increased above 55°C.

● The term "intermittent" is used to identify operating conditions in which no operating or "on" period exceeds 1 hour and every "on" period is followed by an "off" period of at least the same or greater duration.

Preparation of Anodized Aluminum Washers

A detailed drawing of an aluminum washer suitable for use with the 2N301 and 2N301-A power transistors is given in Fig.1. This washer, which is 0.125 inch thick, is easy to fabricate and is relatively inexpensive. The two mounting holes and the clearance holes for the emitter and base pins are drilled or punched in the washer, and any burrs are removed. Prior to anodization, the washers are (1) degreased in a solution of Diversey No.202 (concentration 6 ounces per gallon of water) for 30 seconds at a temperature of 80 degrees centigrade; (2) rinsed in water; (3) etched in a solution of Diversey Aluminux (concentration 4 to 6 ounces per gallon of water); (4) again rinsed in water; (5) cleaned in a concentrated solution of nitric acid; and (6) given another rinse in water. After this preparation, the aluminum washers are suspended in the electrolyte or anodizing bath, which contains 15 per cent sulphuric acid by weight, and a current of 0.5 ampere is passed through the plating circuit for 30 minutes. A schematic representation of the anodizing process is given in Fig.2. The electrolyte is cooled during the process so that its temperature is maintained at 23 degrees centigrade. An aluminum-oxide coating having a thickness of approximately 0.005 inch is

developed on the washer. After anodization, the washers are given a final rinse in boiling water containing 2 to 3 drops of acetic acid per liter of water.

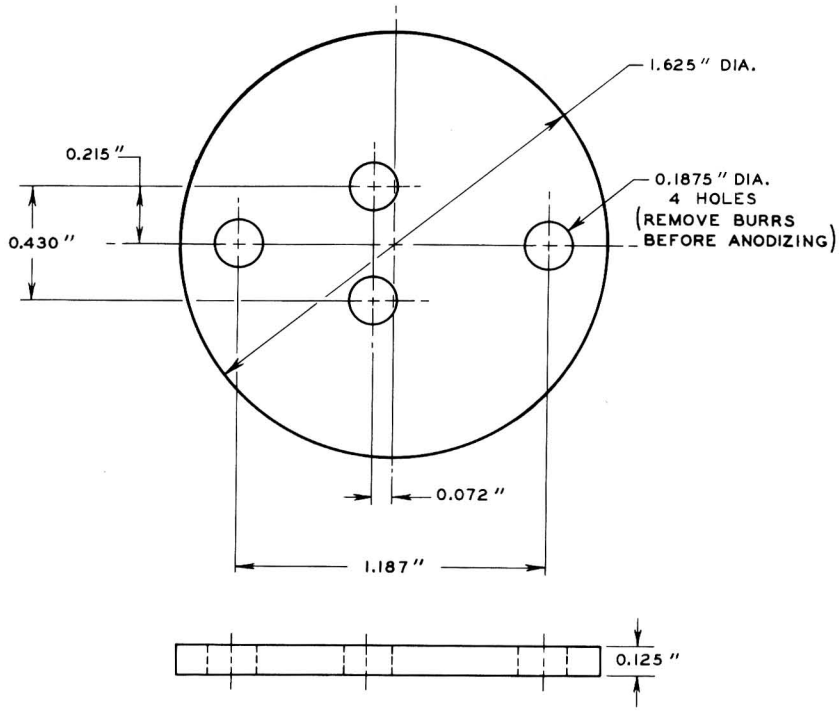

Fig. 1 - Detailed drawing of anodized aluminum washer for use with RCA-2N301 and RCA-2N301-A power transistors.

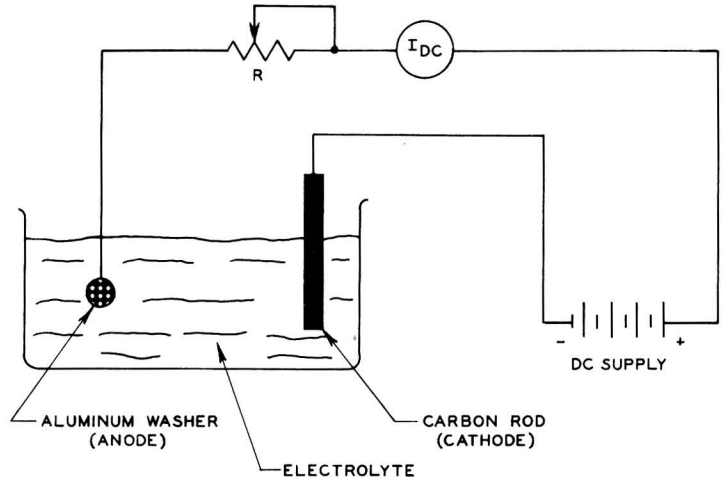

Fig. 2 - Schematic representation of anodizing process.

The ability of the anodized washer to withstand abrasive forces depends primarily on the hardness, as well as the thickness, of the aluminum-oxide coating. In general, an aluminum-oxide coating having a thickness of 0.005 inch or more provides a surface which can withstand the normal abrasive forces encountered in production.

Preparation of Mica Washers

Fig.3 shows a detail drawing of a mica washer suitable for use with the 2N301 and 2N301-A power transistors. This washer, which is 0.002 inch thick, is also easy to fabricate and is relatively inexpensive. The two mounting holes and the clearance holes for the emitter and base pins are punched in the washer. The thickness of 0.002 inch represents the minimum mica thickness which can be handled in production and still provide good electrical insulation and high thermal conductivity without excessive flaking or cracking.

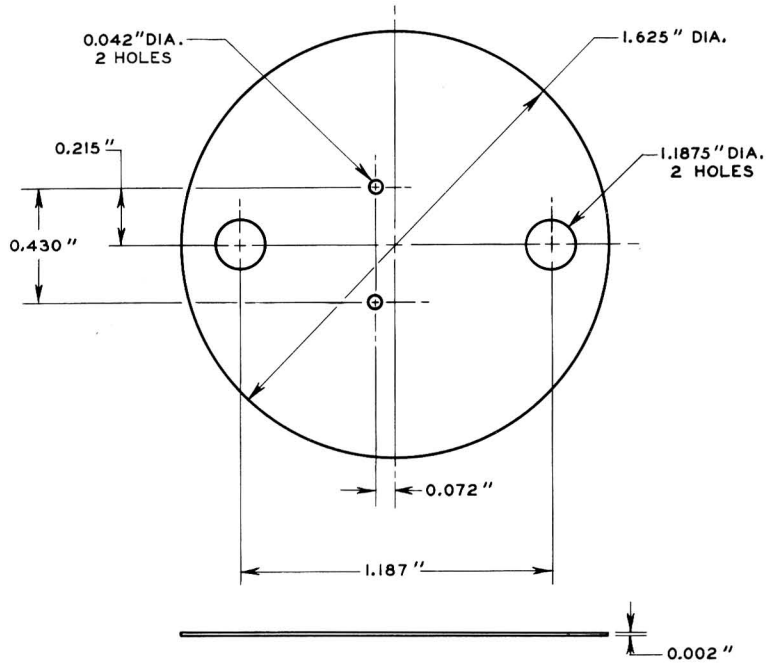

Fig.3 - Detailed drawing of mica washer for use with RCA-2N301 and 2N301-A power transistors.

Mounting of Transistors and Washer to Chassis

As shown in Fig.4, the anodized aluminum or mica washer is mounted between the copper flange of the 2N301 or 2N301-A power transistor and the chassis. All burrs should be removed from holes in the chassis to insure that the anodized insulating coating on the aluminum washers will not be destroyed during mounting. It is important that a fiber washer be used between the mounting bolt and the chassis, as shown in Fig.4, to prevent a short circuit between them. A spring-type lock washer should also be used to compensate for dimensional changes in the fiber washer.

Because either an anodized aluminum washer or a mica washer has relatively high thermal conductivity, the total thermal resistance of the

collector circuit is not appreciably increased by the addition of the washer. Tables II and III show the effects of the washers on heat dissipation to the chassis and to the air surrounding the transistor. As shown in Table II, the heat transfer to the chassis drops less than 10 per cent when either type of washer is used. For a constant power dissipation of 7 watts and transistor-case temperature of 55 degrees

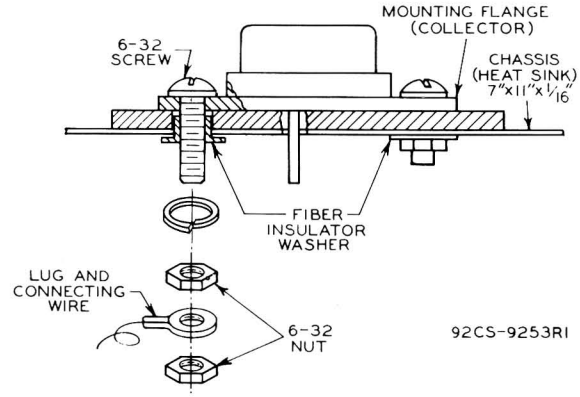

Fig. 4 - Method of mounting anodized aluminum washer or mica washer between power transistor and chassis.

centigrade, the temperature of the chassis is 51 degrees centigrade when no insulator is used and 46.5 degrees centigrade when the anodized aluminum washer is used. When the 0.002-inch mica washer is used, the chassis temperature is 47 degrees centigrade. Table III shows that the heat transfer to the surrounding air also drops less than 10 per cent when either the anodized aluminum washer or the mica washer is used. These tables also show changes in thermal resistance of the heat flow paths when the anodized aluminum or mica washer is inserted.

Table II - Effects of Washer on Heat Transfer to Chassis
(Power Dissipation = 7 watts)

Temperature of Transistor Case (°C)	Insulator	Temperature of Chassis (°C)	Thermal Resistance of Heat-Flow Path from Case to Chassis (°C/W)	Thermal Resistance of Insulator (°C/W)	Breakdown Voltage of Insulator (Volts)
55	none	51	0.57	-	-
55	anodized aluminum	46.5	1.21	0.64	250
55	mica	47.0	1.150	0.580	>250

Table III - Effects of Washer on Heat Transfer to Surrounding Air
(Area of chassis = 77 sq. in.; thickness = 1/16 in.)

Temperature of Transistor Case (°C)	Insulator	Ambient Temperature (°C)	THERMAL RESISTANCE OF HEAT-FLOW PATHS (°C/W)		
			Case to Ambient	Collector to Case	Collector to Ambient
55	none	40°C	2.09	2.5	4.59
55	anodized aluminum	36°C	2.73	2.5	5.23
55	mica	39°C	2.67	2.5	5.17